ANATOMY PHYSIOLOGY AND HYGIENE

HOTZE

LESSONS

IN

Anatomy, Physiology, and Hygiene

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"First Lessons in Physiology," "Questions and Problems in Physics,"
"First Lessons in Physics," etc.

REVISED AND ENLARGED

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PREFACE.

Educators, and the people generally, are agreed that a knowledge of "the machine which we run and which runs us" is of the utmost importance. The force and prominence of this fact have brought about the publication of this volume, which is a carefully revised and greatly enlarged edition of Hotze's First Lessons in Physiology.

In the preparation of this book the authors have kept in view the purposes, needs, and methods of the class-room, guided by their long experience in public school instruction and management. All the best material at command has been carefully examined and freely drawn upon; one of the objects being to have this work fully abreast of the present knowledge on the subjects discussed, as far as its purposes will allow. A simple and clear style of expression has been used so that an intelligent understanding of the human body and its workings may be obtained by the average pupil in our elementary schools.

The subject-matter has been arranged under several chief divisions rather than the old plan of lessons. These divisions being in general the great systems of the human body will, it is hoped, aid the student in a better comprehension of the subject. In the description of each organ the endeavor has been: first, to

present a clear statement as to structure; second, to set forth the functions; and third, the care which the part should receive. In this connection the authors have discussed many disorders and given numerous hints as to treatment. Much care has been exercised in the making and the arrangement of cuts so as to best serve the end in view—that of a correct knowledge of structure. To this same purpose topics, subtopics, and subjects of paragraphs have been indicated by different kinds of type and numberings. In short, all that is possible in arrangement has been done to aid the student.

A separate chapter has been devoted to the subjects of alcohol and narcotics. The views presented are intended to be such as are generally accepted by medical men to be in keeping with the best scientific thought. By being consistent with experience in the world it is thought that the pupil's impressions will remain permanent.

In conclusion it should be mentioned that the great works of Gray, Flint, Dalton, and Huxley have been considered undisputed authority and have been taken as standards. Also the writings of Hitchcock, Cutter, Carpenter, Hutchison, Lankester, Macé, Holmes, Hutchinson, and others have been consulted.

PUBLISHER'S NOTICE.

This Revised and Enlarged edition is intended to meet the demands of the schools to-day. The First Lessons on Physiology will still be published for classes already using it and for more elementary work.

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I.

INTRODUCTION.

What a piece of work is man! How noble in reason! how infinite in faculty! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals.—Hamlet.

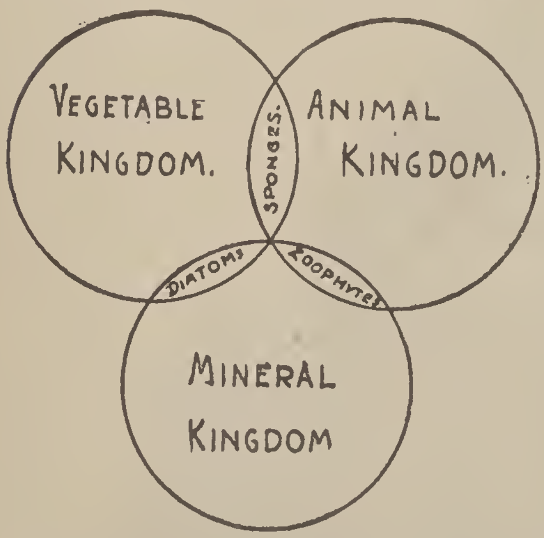
ANATOMY, PHYSIOLOGY, AND HYGIENE.

I. Introduction — General Science.

All matter may be divided into two classes: **Organic** and **Inorganic**, which may also be termed, *living* and *lifeless*. Living objects are plants and animals;—lifeless, such substances as mineral-coal, iron, sand, rocks, water or air. Although in the present advanced state of science it is often difficult

to draw the line of difference between living and lifeless things, yet that distinction is still maintained, because between things having no life and substances such as wood or flesh, the differences are very striking.

Organic matter includes the animal and the vegetable worlds — *living things*, while *inorganic* matter comprises the mineral world — *lifeless substances.*



Organic (from *ergon*, work), having organs, or working parts.

Inorganic, not having organs; that is, having no working parts.

The plant is the *connecting link* between the *mineral* and *animal* kingdoms.

Animals have life and nerve energy. Plants have life without the nerve energy. Minerals lack both life and nerve energy.

The plant *germinates*, the animal *breathes*, while the stone does *neither.* In plants and animals there is *change* of parts, but in minerals there is *no* change. This germinating, breathing, and changing process is dependent upon *life.* The principle, termed *life*, is always present in *organic* but never

in *inorganic* matter. In fact, this is one of the most marked differences between the two kinds of matter.* In other words, an organism is derived from a parent; inorganic matter is not.

Change is the great law of life.

Organisms live, develop, and die; inorganic bodies are said not to live, develop, or die.

The further distinction between these two great classes of materials is based upon **form, coherence, growth, and composition.**

Form. — The sharp angles and straight lines of a crystal, the nearly regular features of most fragments of rock, are characteristic. On the other hand, notice the general absence of straight outlines in living structures, the curved shape of leaves and flowers, the rounded forms of the higher animals, and particularly those of the human body. Distinguish between the fracture of a lump of mineral-coal and that of charcoal. It will be your impression that inorganic matter, generally speaking, assumes forms of a severer pattern.

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* *Matter* is anything that occupies space. A distinct portion of matter is called a *body*. Matter may exist in three states; as, solid, liquid, and gaseous, respectively represented by *ice*, *water*, and *vapor*.

Science is classified knowledge.

Coherence. — Particles of sandstone cling together owing to cohesion, without having any other mutual relation. A fragment of sandstone truly represents the original rock of which it once formed a part, inasmuch as it possesses all the properties of the rock. The particles of a tree cohere likewise, but they are closely dependent upon one another. A piece of wood does not strictly represent the tree from which it came, because in different parts of the same tree the wood may have different properties. Hence, the coherence of organized matter greatly differs from that of substances of the inorganic world.

Growth.— If the growth of a crystal, or of an ordinary rock, could be plainly observed, it would be found to consist in a mere adding of particle after particle on the outside, without any interior development. Nor would it be found accompanied by decay, or repair, going on at the same time; whereas, plants and animals, during their growth, always decay in part — that is, while they are building up, they also lose waste matter, only the building up is far greater in quantity than the waste. This is true, regardless of the manner in which the plant grows, whether, for example, like most of our trees, it grows by adding superficial

layers or rings around the stem, or, like Indian corn, by developing from within. Animals grow by interior development. Carbonic acid gas and water-vapor are two products of animal waste. Plants and animals make up the organic world, or world of organisms, and all organisms differ in their manner of growth from objects belonging to the inorganic world.

Inorganic substances present a mere building up without corresponding development of all parts; while an organism develops throughout, and thereby attains gradually to a higher organization. The grain of corn generates the plant; the egg brings forth the bird; the infant develops into the full-grown man. Nothing of the kind takes place in inorganic matter.

Composition.—Copper, gold and iron are examples of elemental bodies; on being subdivided repeatedly, each yields its like again. Water is an example of a compound body; it is composed of, and may be resolved into, two elements,* hydro-

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* About sixty-five kinds of simple substances, termed elements, either singly, or with two or more united, make up every material known. An *element* is a simple substance; that is, composed of only *one* kind of matter, as, *oxygen*, while a *compound* is made up of two or more elements, as *sodium*

gen and oxygen. Clay, another compound body, consists of three or four elements. All these substances are inorganic; and nearly all inorganic substances are less complex in composition than organic bodies, such as wood or flesh. They are also more stable; that is, they do not decompose so readily.

The Structure of a Higher Animal, required for the complete display of its capacities, may be represented thus:—

1. An apparatus to convert food into a fluid which will develop and maintain the body, and to remove waste materials.

2. A system of vessels to convey this fluid to all parts of the body.

3. A muscle or heart, which, by contracting and relaxing, pumps the fluid into the vessels.

4. A mechanism for respiration, so as to purify the fluid by a fresh supply of oxygen.

5. Contractile cords or muscles to set the different parts of the body in motion.

6. A mass of nervous matter, with nerve fibres spreading over the body, to receive impressions from

---

chloride — common salt. Salt contains *sodium* and *chlorine*, two elements, chemically united.

the outer world, and to convey manifestations of will, etc., to the various portions of the body.

The discussion of plant and animal life is embraced in many sciences. BIOLOGY, in a broad sense, means a discourse or treatise upon *life*, which may be either animal or vegetable, expressed in Zoölogy and Botany. In a narrower sense, it is applied to the study of animals. One of the divisions of Biology is *Physiology*. *Physiology* is the science which describes the action, functions and uses of animal organs.

When the study relates to man, it is styled *Human Physiology*, but when referring to the lower animals, it is termed *Comparative Physiology*.

Divisions of the Subject. — Physiology proper naturally divides itself into three departments: *Anatomy*, *Physiology*, *and Hygiene*. *Anatomy* treats of the structure of the body and its individual parts.

Physiology,* in a restricted sense, treats of the functions of the body and its organs.

Hygiene treats of the laws of health.

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* It will be noticed that the term *Physiology* is used in two senses.

The value of a thorough knowledge of physiology, in all its departments, can scarcely be estimated. If one be well, a knowledge of physiology will keep him so. While on the other hand, if one be sick, the same knowledge will enable him to regain that priceless treasure — good health. A fitting paraphrase of the well-known proverb would be "Good health is to be chosen rather than great riches." How many thousands are the victims of disease and premature death on account of ignorance of the laws of their being. What pleasures are added to the joys of existence by "eating to live" rather than "living to eat!" *Mens sana in corpore sano* is a maxim whose truth is clear. The ancients were not so far advanced in the sciences as the moderns are, yet we are indebted to them for many valuable truths. Chilo, one of the greatest of the ancient philosophers, expressed this wise saying: "Know thyself." Then, let him who would fulfill the laws of life know *himself*.

REVIEW QUESTIONS.

1. What is science? Give the states of matter.

2. Define matter, and name its classes.

3. Why is it difficult to draw a distinction between the two great classes of matter?

4. Give the divisions of organic matter.

5. What is the derivation of the word organic?

6. In what way is the plant the connecting link between the mineral and the animal kingdoms?

7. Name the three kingdoms of nature and state how they differ from one another.

8. How are these kingdoms closely related?

9. What is the great law of life? What is life?

10. Explain the difference in derivation between organic and inorganic matter.

11. What can organisms do?

12. Give the leading distinction between these two great classes of matter.

13. *Form:* What is characteristic of crystals? Of living structures? What is meant by "inorganic matter, generally speaking, assumes forms of severer pattern?" What have you noticed in snow crystals as to beauty and regularity of form?

14. *Coherence:* How does the coherence of organic and inorganic matter differ? What holds the living body together?

15. *Growth:* Explain the difference in the growth of crystals and organic bodies. What opposite processes are going on in plant and animal bodies at the same time? In what two ways do plants grow? Give examples of two kinds of plants differing in manner of growth. How does the growth of animals differ from that of plants?

16. *Composition:* What is an element? How many elements are there? By what science are elements united to form compounds? Define compound. Name a compound, giving the elements composing it. Which are more complex in composition, organic or inorganic "bodies?" Which are more stable?

17. What are required for the structure of a higher animal?

18. In what way is the discussion of plant and animal life a broad one?

19. What are some branches of Biology? What one relates to the lower animals?

20. Define Physiology, and give its two phases.

21. Give the divisions of Physiology, defining each.

22. For what reasons ought one to study the subject of Physiology? What is the way of the world regarding "good health?" Whom should we blame for our ill-health? Explain the meaning of the phrases: "Eating to live," and "Living to eat." Are there some notable exceptions to the sentiment, contained in *mens sana in corpore sano?* Give an instance, or two, to show that the ancients were very wise. To what country did Chilo belong? What can you tell about him? What does "Know thyself" mean? Give an instance where a knowledge of physiology was very beneficial.

BLACKBOARD OUTLINE.

Matter.
- 1. Organic (living)
  - Animal Kingdom.
  - Vegetable "
- 2. Inorganic (lifeless) Mineral "

Distinctions between Organic and Inorganic Matter.
- 1. Form.
- 2. Coherence.
- 3. Growth.
- 4. Composition.
- 5. Derivation.*

Biology.
- 1. Botany.
- 2. Zoölogy
  - Human Physiology.
  - Comparative Physiology.

Physiology.
- 1. Anatomy.
- 2. Physiology.
- 3. Hygiene.

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* That is, organic matter is derived from a parent, while inorganic is not.

II.

THE OSSEOUS SYSTEM.

Man is all symmetrie
Full of proportions, one limbe to another,
And all to all the world besides,
Each part may call the farthest, brother,
For head with foot hath private amitie,
And both with moons and tides.—Herbert.

II. The Osseous System.

1. BONES.

Experiment. — Place the thigh-bone or "drumstick" of a chicken on a shovel and put the shovel in the fire. Leave it there a few minutes. Take it out of the fire and examine. You will observe that the shape of the bone is unchanged, but that it is no longer strong and tough; that it will not support as much weight as before. This is the condition of the bone when it has lost its *animal* matter.*

Experiment. — Place another bone of the same kind in a glass or bottle filled with common vinegar, or diluted muriatic acid mixed in the ratio of a wine-glass of acid to a pint of water. Leave the bone there two or three days. Now remove the bone and wash it in clear water. You will observe that the shape is unchanged, but that its

* Bones thus burned furnish the phosphorus of the chemist. If the animal matter is only charred the "bone-black" of commerce is made.

firmness is destroyed; that it may now be bent without breaking — indeed, if the experiment is carefully performed it may be tied into a knot, as seen in the accompanying cut. This is the condition of the bone when it has lost its *mineral* matter.

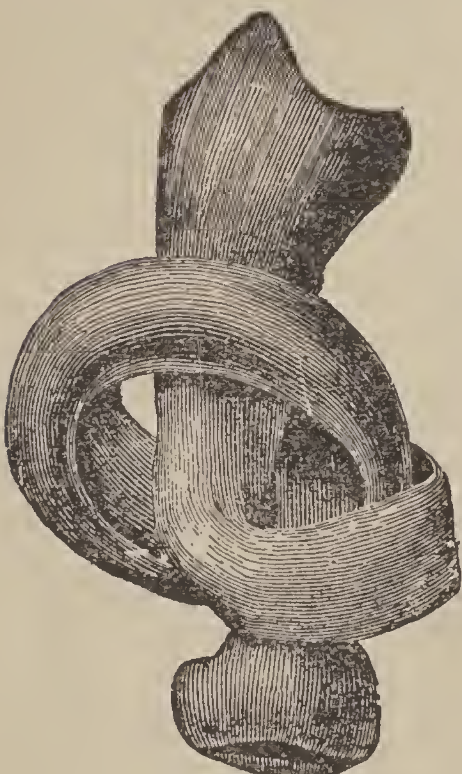


FIG. 1.

The Composition of bones is now seen to be a close union of animal and mineral substances. In the normal bone both substances exist in definite proportions. In youth these are nearly half and half. A deficiency in the mineral ingredients (chiefly lime), as is the case with bones in early life, causes them to bend readily; while an excess of lime, always found in the bones of old people, renders the bones brittle.

The entire bone is at first composed of cartilage, which gradually *ossifies* or turns to true bone.* Certain portions near the joints are long delayed in

* The ossification of the bones on the sides of the head, for example, begins by a rounded spot in the middle of each one. From this spot the ossification extends in every direction.

this process, and by their elasticity assist in breaking the shock of a fall.

The Structure of bones shows a network of small canals and layers of bone substance. Bones are less dense at their centers; many of them contain a fatty substance called the marrow. Bones grow and constantly renew their particles.

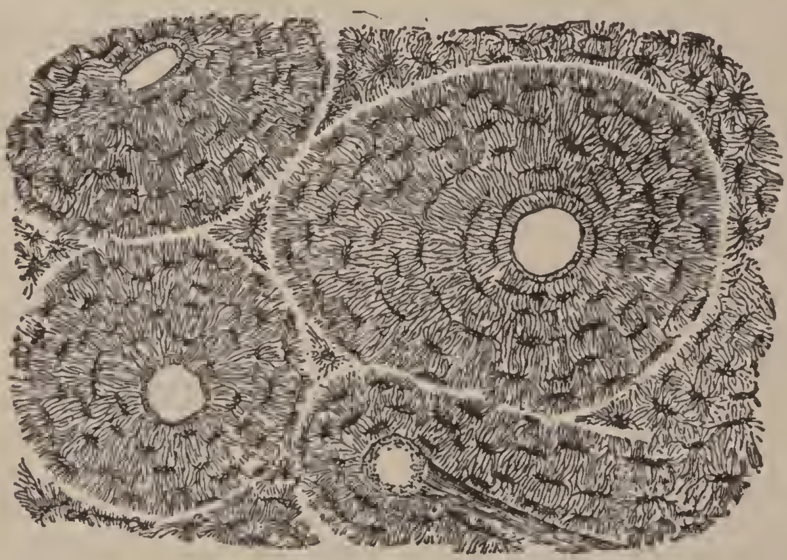


FIG. 2.

A thin slice of Bone, highly magnified, showing the lacunæ, the tiny tubes (canaliculi) radiating from them, and four Haversian canals, three seen crosswise and one lengthwise.

The Growth of Bones.— Every bone of an adult was at one time a cartilage, as we have said above. It did not become hardened uniformly throughout its mass, but the process of ossification — that is, the deposition of mineral matter in the cartilage — took

place first at particular points, called the *centers of ossification*. Thus the long bones of an infant contain at least three such centers or bony masses, one in the middle part of the bone (then as yet a cartilage), and one situated toward each end. In the adult these three osseous centers are united into one solid bone.

When the edges or ends of bones in their growth come to touch each other, they either form *joints* or articulations, in order to enjoy motion upon each other; or they grow firmly together, forming *sutures*. Sutures may be readily ascertained in the bones composing the skull.

2. THE SKELETON.

The Skeleton, or framework of the "house we live in," consists of all the bones in the human body, the total number of which is about two hundred and six, excluding the teeth. Besides, there is found a firm, elastic tissue called *cartilage* or gristle, such as the outer ear or the lower part of the nose. These cartilages are found mainly at the joints between the bones as cushions.

The skeleton is usually divided into three distinct portions: the *head*, the *trunk*, and the (upper and lower) *limbs* (Fig. 3). It contains three cavities;

the uppermost is a hollow box of bone, the *skull*, or cranium; this contains the brain, and has attached to it the jaws and the remaining bones of the head.

Below this a bony case or basket is seen, called the *chest* or *thorax;* and further down a bony basin, the *pelvis.* The chest and the pelvis, together with the backbone, form the trunk of the body. The arms, or upper extremities, are attached to the upper part of the chest by means of the *collar-bone* and the *shoulder-blade.* The legs, or lower extremities, are fastened to the lower part of the trunk.

Bones, like all organic structures, consist of *cells*, that is, of cellular tissue; the cells are more or less of a hexagonal form. Bones are renewed even more rapidly than any other portion of the body except the nails, the skin and the hair. The natural process by which broken bones are restored is remarkable. The immediate result of the injury is an effusion of blood around the broken parts. This is soon replaced by a watery fluid, which, after some time, thickens into a jelly-like mass. In a month or two this mass hardens, and slowly acquires the properties of bone; months after this the bones, if carefully treated, unite perfectly.

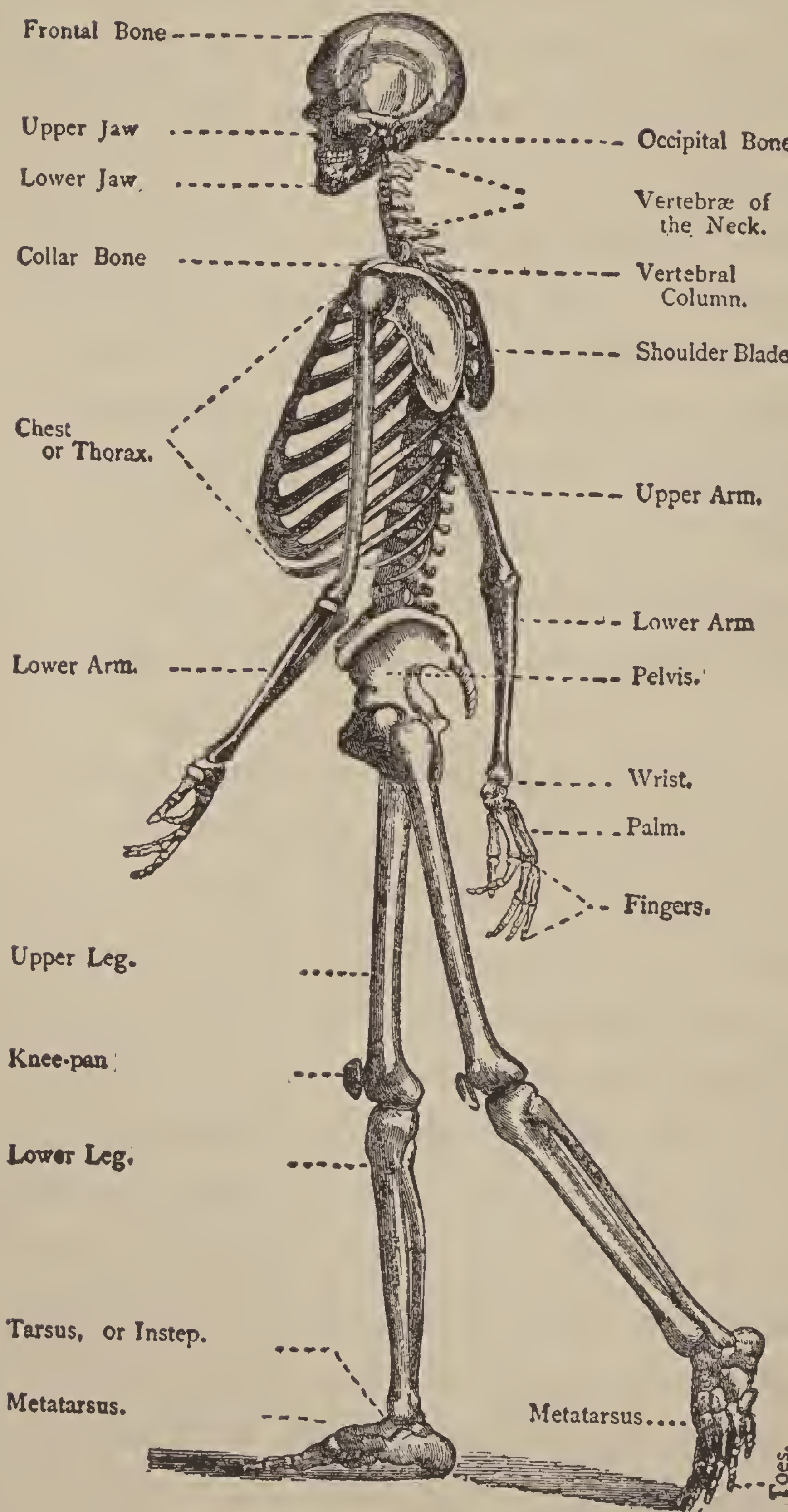

Frontal Bone
Upper Jaw
Lower Jaw
Collar Bone
Chest
or Thorax.
Lower Arm.
Upper Leg.
Knee-pan
Lower Leg.
Tarsus, or Instep.
Metatarsus.
Occipital Bone
Vertebræ of
the Neck.
Vertebral
Column.
Shoulder Blade
Upper Arm.
Lower Arm
Pelvis.
Wrist.
Palm.
Fingers.
Metatarsus
Toes.

FIG. 3.

The Head (Fig. 4) consists of the bones of the skull, face and ear. Its principal parts are:—

1. The *frontal bone*.

2. Two *side bones*, which form the uppermost part, and part of the right and left sides of the skull.

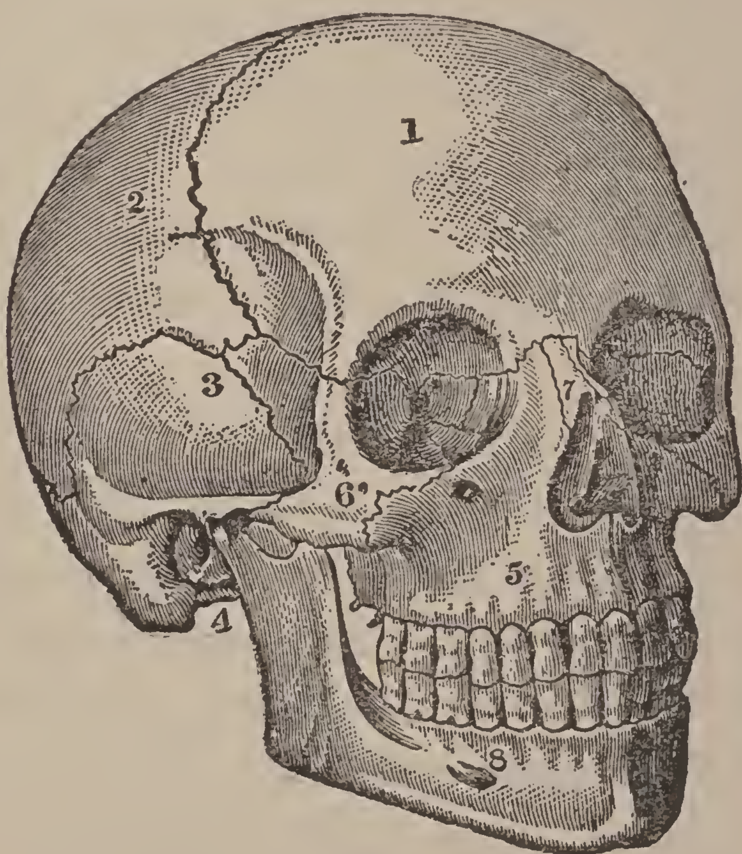


FIG. 4.

3. Two *temporal bones*, one on each side of the lower part of the frontal bone.

4. The *occipital bone*, extending down the neck.

5. The *upper jaw*. 6. Two *cheek bones*. 7. *Nose bone*.

8. The *lower jaw*, easily separable from the remaining parts of the head.

9. The *sphenoid bone*, forming the base of the skull (not visible in Fig. 4).

The upper jaw contains the upper row of teeth, the lower jaw, the lower. The lower portion of the nose consists of cartilage, which remains soft during life. The roof of the mouth is a thin but hard bone, forming part of the upper jaw.

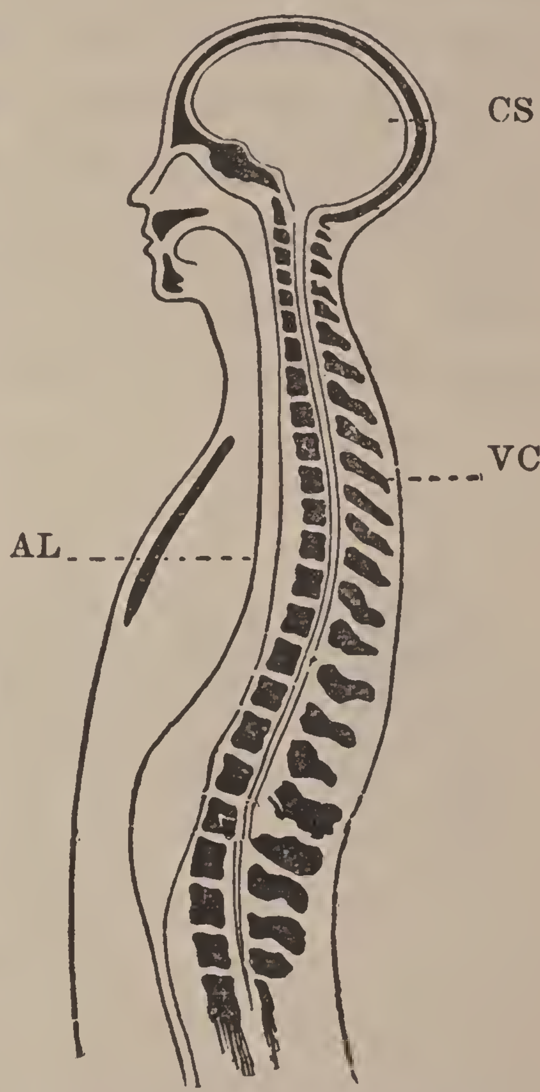
The various bones of the head are firmly joined together, although they contain fissures and holes.

According to the preceding, the skeleton is composed of head, trunk and limbs; and the trunk separable into chest or thorax, and pelvis. The young student will do well to observe that the head contains two distinct cavities; the cavity of the skull and that of the face, which are entirely separated from each other. The former contains a mass of nervous substance, which is called the brain. This substance is continued down to the lower end of the pelvis in the shape of a downward tapering cord, called the spinal cord. This cord together with the brain pass under the name of *cerebro-spinal axis.* Thus, we discover that the skull together with the vertebral column (Fig. 5) form a tube very much

expanded above and exceedingly narrow at its lower end; and that this tube is completely insulated, in the first place, by the bones of the skull, and secondly, by the vertebral bones or *vertebræ*.

The other cavity, that of the face, contains the mouth. The mouth is part of another tube, called the *alimentary canal*, which extends from the mouth through the entire length of the trunk in front of the vertebral column (Fig. 5). The cavity of the mouth may be considered the expanded upper end of the alimentary canal, just as the cavity of the skull forms the upper expanded end of the tube containing the spinal cord.

FIG. 5.



VERTICAL SECTION OF THE HUMAN BODY.

A. L. — Alimentary canal.
V. C. — Vertical column.
C. S. — Cerebro-spinal axis.

The cavity of the mouth contains two rows of teeth, one in the upper jaw, the other in the lower. Each tooth has *crown*, *neck* and *fang* or *fangs*. The crown is the portion which projects beyond the gum.

The neck is that portion immediately below the crown and on a level with the edges of the gum. The fang, or fangs if there be more than one, comprises all below the neck (Fig. 6).

The crown is covered with an exceedingly hard substance, called *enamel;* this is the hardest portion of a tooth, and the hardest substance in the human body. It forms a very thin layer, and serves as a protection to the principal constituent of all teeth,

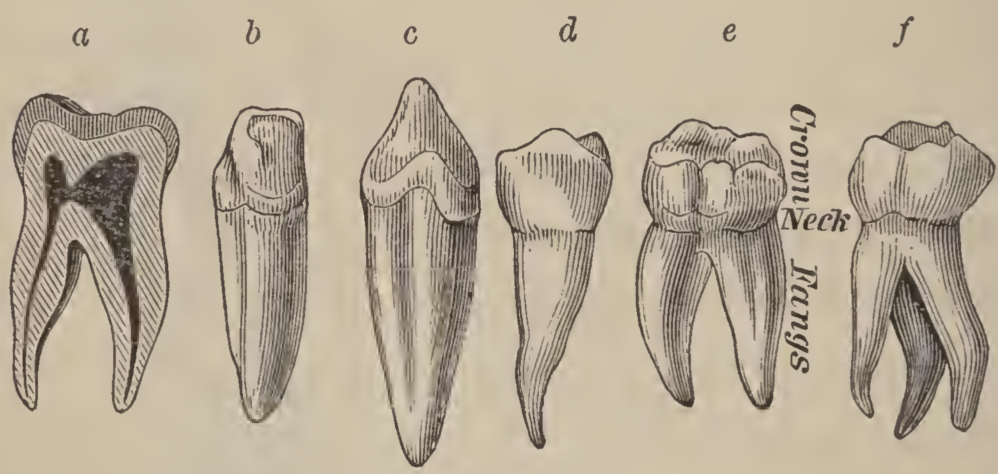


FIG. 6.

the *dentine* or ivory. This dentine is hollowed out into a cavity, which contains a very sensitive mass of nervous matter, the tooth pulp (Fig. 6, *a*). Teeth are partially composed of bony matter; they differ from bones in possessing enamel and dentine, which bones have not. Teeth have no growth.

There are thirty-two teeth in number, sixteen in each jaw. The four front teeth in each jaw are

adapted for cutting purposes, and therefore named *incisors* (*b*). On each side of them is a tooth with one cusp — that is, with a pointed crown (*c*). It is called the *eye-tooth*, or, because it resembles the long, tearing tusk of the dog, the *canine*. Next on either side is a tooth (*d*) with two cusps on the crown, larger than the preceding teeth, and called *bicuspid*. Adjacent to it are teeth with more than two cusps, the *molars* or grinders (*e* and *f*), the broadest and most powerful of all. The crowns of the molars in the lower jaw have four or five cusps, while those in the upper have one cusp less.

In the early period of life, each jaw has ten temporary or milk teeth. At the age of six or eight the upper portions of these teeth fall out or are "shed," while the fangs are absorbed. Then appears the second or permanent set of teeth, thirty-two in number. The following formula shows that the molars of the child are replaced by the bicuspids of the adult: —

Formula of Arrangement and Number of Teeth.

		Mo	Ca	In	Ca	Mo		
Temporary Teeth.	Upper,	2	1	4	1	2	= 10	= 20
	Lower,	2	1	4	1	2	= 10	

		Mo	Bi	Ca	In	Ca	Bi	Mo		
Permanent Teeth.	Upper,	3	2	1	4	1	2	3	= 16	= 32
	Lower,	3	2	1	4	1	2	3	= 16	

Important Facts. — Sudden changes of temperature, owing to very cold or very hot food or drink, are dangerous to the teeth, as they may cause the enamel to crack. Acids and metal toothpicks should be avoided. Teeth require frequent cleansing with water and a soft brush, especially after meals. Any injury to the enamel is irreparable, and, as it causes the dentine beneath to decay, may involve the loss of the tooth.

Therefore cracking hard nuts with the teeth, biting thread, etc., should be avoided. Furthermore, the teeth should be examined at least once a year by a dentist, so that if any small cavity should be found it may be filled and further decay prevented. At such an examination the tartar, a deposit at the edges of the gums, which is very injurious, should be carefully removed.

The Trunk constitutes the second chief division of the skeleton.* This is a very important part of the

* The carcass of a quadruped, if placed in a wooden box punctured on all sides, and buried in the ground, close by an ant-hill, will after a few weeks be reduced to a skeleton, which may be used to advantage in studying the human skeleton.

framework of the human body. It is complex in structure and has the great cavities which contain the vital organs of the man. There are two of these cavities. The upper one, or *chest*, contains the heart and lungs; the lower one, or *abdomen*, holds the stomach, liver, kidneys, and other organs. The bones of the trunk may be divided into those of the *spine*, the *ribs*, and the *hips*.

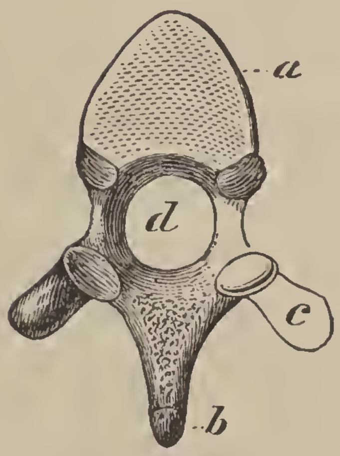
The Spine is the upright column (Fig. 5) called the *back-bone*, by which the head is supported. It consists of twenty-four separate vertebræ, which are so fastened together that the entire number appears as an unbroken pillar, forming the central, most important, and, let us add, the most wonderful part of the skeleton. Nearly all the organs of the body seem to rely upon it for their support. It helps to form the back wall of the chest and abdomen, which are maintained by the pelvis, or *haunch bone*. The spine rests upon the pelvis like a column upon its base.

The Vertebræ and joints of the back-bone may be ascertained by the touch; they begin with the back part of the neck and pass down to the pelvis. In a similar manner locate the ribs, which extend from the right and left of each vertebra in the thorax and en-

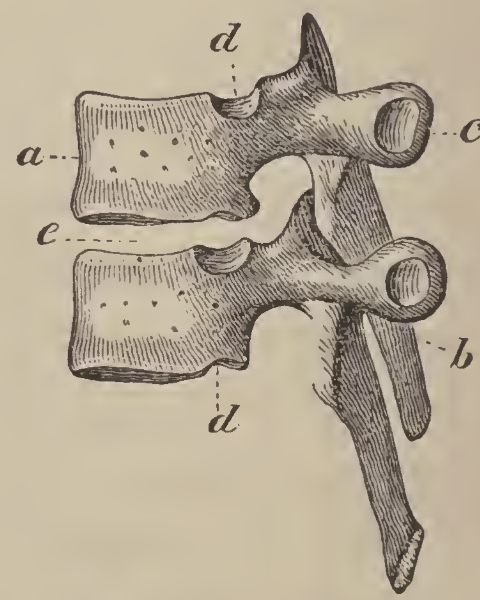
circle the chest. They are fastened in front to the breast-bone, or *sternum*. Find the two collar-bones, or *clavicles*, and observe their form. Next examine the two shoulder-blades; together with the clavicles they form the shoulder, and protect the lungs from above.

The vertebræ are perforated, that is they contain a

FIG. 7.



A Vertebra.
Horizontal Section.



Two Vertebræ.
Side View.

nearly oval cavity about an inch wide, filled with the spinal cord (Fig. 7, *d*). This cord extends down to the lower end of the pelvis. The spinal column protects the spinal cord within; it serves to bear the head aloft and to give the body its erect position. Between the vertebræ are the usual cartilaginous

cushions. These are thick and strong and together with the double curve of the spine prevent any jar from reaching the brain when we jump, run or fall. Here we may observe the great precaution which is taken to guard the precious organs.

Each vertebra presents the appearance of a hollow cylinder, to the rear portion of which are attached seven superficial elongations, or *processes* (Fig. 7, *b* and *c*). To these processes are joined ribs, ligaments, and muscles.

FIG. 8.
The Spine; the seven vertebræ of the neck, cervical; the twelve of the back, dorsal; the five of the loins, lumbar; *a*, the sacrum, and *b*, the coccyx, comprising the nine "false vertebræ."

The Ribs, twenty-four in number, are in pairs in the two walls of the chest. The number of ribs fastened to the sternum is fourteen, seven on each side. The eighth and ninth ribs, on each side, do not reach far enough to the front; the tenth, eleventh, and twelfth are shorter yet. These ten ribs are called the "*false*" ribs.

The form of the chest when in its natural condition is that of a cone with the small end upward. Being long and slender the ribs give lightness; and curved in direction, give strength; with cartilaginous connection in front they give elasticity,—all of which are necessary for the protection of the delicate organs within as well as their action.

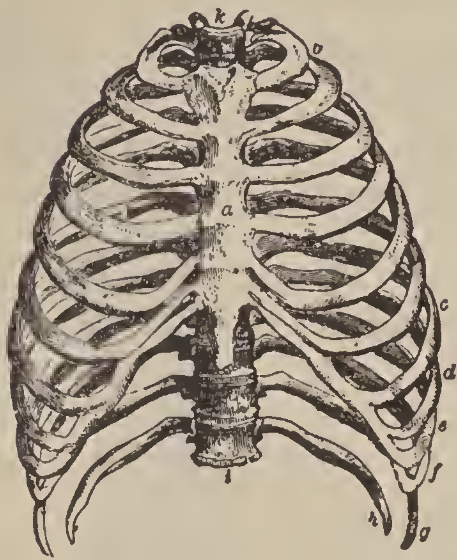


FIG. 9.

The Chest, or Thorax. *a*, the sternum; *b* to *c*, the true ribs; *d* to *h*, the false ribs; *g*, *h*, the floating ribs; *i*, *k*, the dorsal vertebræ.

The Pelvis supports the spinal column and the abdomen. It is formed by the two hip-bones, which are held together by the lower part of the spinal column, the *sacrum*.

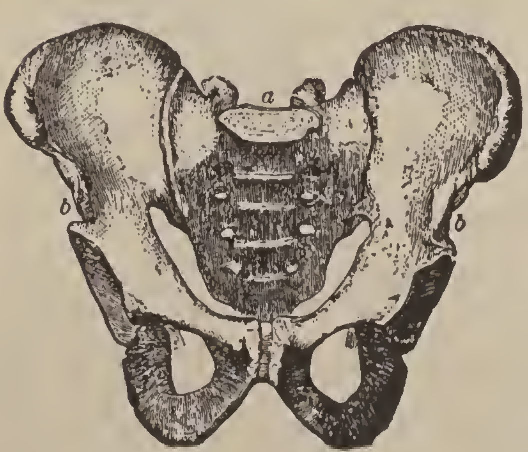


FIG. 10.

The Pelvis. *a*, the sacrum; *b*, *b*, the right and the left innominatum.

During the day the spinal column, while in erect position, supports the weight of the head, arms, and nearly the entire trunk. This compresses the layers of cartilage between each pair of verte-

bræ so as to diminish the length of the column. Hence, the human body is actually a little shorter towards evening, and resumes its normal length when lying in a horizontal position, or after a night's rest. Elderly persons shrink in height, because their intervertebral cartilages harden and become thinner; this accounts for their stooping posture. Persons in the habit of bending the head forward too far compress the front part of those cartilages, while the rear portion thickens. In course of time the cartilages lose their elasticity, and the spine becomes curved or "crooked." The erect position of the spinal column is one of the essential requirements of health.

The Limbs.— Two sets of extremities branch from the trunk, viz.: the upper and the lower. They are very similar in structure.

Examine your arms and locate their bones. You will find a long bone in the upper arm, and two long bones in the lower. So there is in the upper leg a long bone, the longest and strongest bone in the skeleton; and there are, also, two long bones in the lower leg.

The Shoulder is made up of two bones, the collar-

bone (*clavicle*), and the shoulder-blade (*scapula*). The clavicle is a long slender bone almost the shape of the italic *f*, named from *clavis*, the Latin word for key, which the bone resembles in shape. This bone holds the shoulder-point or scapula back. The scapula is a thin, flat, triangular bone resting against the back of the chest and formed to make the foundation for the muscles of the shoulder.

Bones of the Arm and Hand.

FIG. 11.

The Long Bone in the upper arm is called the *humerus*.

The Bones of the Forearm are the *radius*, which is on the side with the first finger, and the *ulna*.

The Hand (Fig. 11) is composed of three parts: the fingers, the palm, and the wrist. The wrist contains eight little bones, placed in two rows; together with the bones of the forearm, they form the wrist-joint. The palm has five bones. The four fingers have three bones each; the thumb contains only

two. The entire hand, therefore, contains twenty-seven bones.

The Foot, in a similar manner, is composed of the toes, the metatarsus, and the tarsus, or instep. The great toe contains two bones; the remaining toes, like the fingers of the hand, have three bones each (Fig. 11). The instep has seven bones; the metatarsus, five. In all there are twenty-six bones in the foot. The heel supports the rear portion of the foot, or the whole body when the body is in erect position.

The Knee-Pan covers the forepart of the knee-joint.

The mechanism which adapts the limbs in the human body to their manifold uses, is remarkable for its effective plan and devices. No animal exhibits a system of joints which is movable in so many directions, and yet is so firm and stout. No animal possesses such gracefulness in the motions of its limbs, combined with so vast a capacity of exertion and endurance.

The limbs are joined to the trunk in a manner such that they enjoy motion in every direction — upward, downward, forward, backward, and in a circular manner. This is secured by a *ball-and-socket* joint where the globular-shaped head of a bone plays in a

cup or socket. The elbow and the ankle have each a *hinge-joint*, which allows forward and backward motion only.

The foot does not rest upon its whole lower surface, but, having the form of an arch, it touches the ground only at the heel and at the ball of the toes in front. All the bones composing the arch, or "hollow of the foot," are fastened to each other by ligaments in such a manner as to give them a large amount of spring-force with which to resist the effects of pressure produced by the weight of the body and by the jar against the ground. To convince one of the truth of this, he needs but place the hollow of the foot upon the round of a ladder.

Ligaments and Joints.— The movable joints are fastened together by ligaments,— firm fibrous bands with very little mobility. The bone to which a ligament is fastened may be broken by an accident, without harm to the ligament itself. The ligaments are tough and not easily hurt; but when we do "sprain" a joint, which means that we have torn or overstretched its ligaments, they recover slowly. If our joints were formed by the direct contact of bones, these bones could scarcely play upon each other; hence, there is cartilaginous tissue between them, to give them a greater or less amount of play and elasticity. In the

movable joints the surfaces which play upon each other are covered with cartilage. Moreover, they are enveloped by a sort of sac, which secretes a lubricating fluid resembling the white of an egg, called synovia.

The joints of the body seem to be movable; but many, like the joints of the head-bones, are fixed, in the manner of the joints of a chair or table. In the spine the joints have little motion, but are not freely movable like the joints of the limbs. The joints may, then, be classed as,—

Immovable.
Slightly movable.
Freely movable.

The Movable Joints are of several kinds. Chief among these may be mentioned, the *hinge* joint, represented by the elbow and ankle; the *ball and socket* joint, of which the articulation of the femur and pelvis is an example.

Important Facts. — Animals can not move their claws separately; man is able to move any of his fingers independently. No animal except the bat is competent, with its fingers, to make a span equal to the entire length of the hand. While many an animal has something like fingers, while the bird

possesses a flying apparatus, and the horse greater capacity for running than man, man alone has so perfect a machine as the human hand with which to execute such complicated motions and to assume such manifold positions and forms.

Cartilage. — Examine, and compare with each other, the nasal cartilage, the external ear, and the gullet of a bird. The first is an appendage to a bone, the second is not directly connected with any bone, the third is a structure entirely independent of bones. All three are illustrations of a dense, firm substance, called cartilage, or gristle. It is nearly related to bone, but lacks the mineral ingredients of bone, and is, therefore, softer and more elastic.

The Chief Uses of Cartilage are the following: —

(1.) To yield smooth surfaces for easy friction in the joints; and to act as a cushion in shocks.

(2.) To fasten bones together without destroying freedom of movement, as between the vertebræ.

(3.) To serve as a firm yet not unyielding framework, as in the larynx and trachea.

(4.) To adapt itself to all purposes where firmness, toughness, elasticity, and strength are required.

The Larynx and Trachea. — To the rear of the tongue is an aperture, the *glottis*, with a sort of

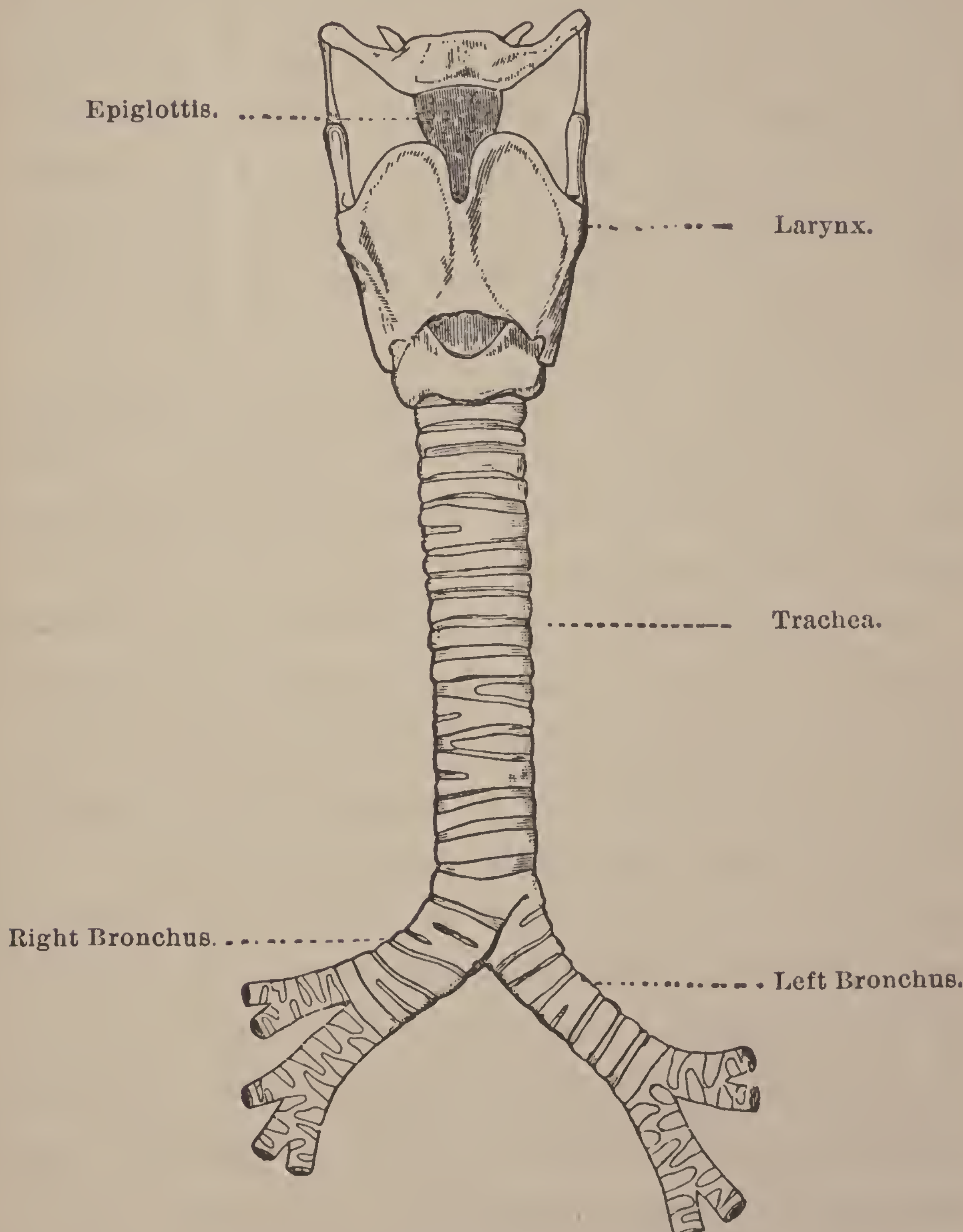


FIG. 12—LARYNX AND TRACHEA.

fleshy cover, the *epiglottis* (Fig. 12). This aperture leads to a cavity, the larynx, whose sides are composed of cartilage.

The lower continuation of the larynx forms a long tube, the *trachea*, or windpipe, composed of cartilaginous rings, some of which may be felt from without. These rings are complete only in front; in the rear where the trachea rests against the gullet, their ends are connected with each other by a thin membrane and by muscular fibres.

The trachea, after entering the thorax, separates into two branches, the right and left *bronchi*. These enter the lungs and divide further into a great many smaller bronchial tubes.

The larynx is the organ of the voice. It contains within its cartilages, immediately below the epiglottis, two elastic lips, known as the vocal cords. These cords are controlled by certain muscles, so they can close the larynx against the passage of air to or from the lungs. They can also be relaxed, or shortened and lengthened, so as to throw currents of air passing between them into vibrations — that is, so as to produce sound. During inspiration the vocal cords are widely separated; during expiration they relax somewhat, and are nearer together.

3. FUNCTIONS OF THE OSSEOUS SYSTEM.

The Functions of the bones in the human body are comprehended by the terms *protection*, *support*, and *motion*.

The bones of the skull form a box, the walls of which are an excellent protection for the delicate organ contained, the brain.

The frontal bone projects over the eye, forming a shield for the eye-ball.

The ribs and the spine constitute the conical box in which the vital organs, the lungs and the heart, are encased, very carefully guarded from harm.

The great column, the spine, so wonderfully constructed, is the chief support for the entire body. Bones of the lower limbs likewise are for support as well as for locomotion. The foot with its graceful arch and all its bones so carefully adjusted is admirably constructed for sustaining the weight of the body to the best possible advantage. And few persons even consider how important this part of the skeleton is. Consequently it is generally mistreated. Ill-shaped shoes fashioned according to some abnormal imagination rather than in keeping with nature's model are universally

sought, thus abusing that which was constructed for satisfaction and use.

The great variety — almost endless variety — of motions of which the body is capable is directly due to the great number and varied shapes of bones in the skeleton. Study for a moment the motions of the arm and hand. How numerous and how varied in direction and position! This could not be were it not for the great number of bones in these members of the body. True, not to the bones alone is all this due, but in conjunction with ligaments and muscles.

From these statements of facts it may be seen that, in truth, the functions of the skeleton are protection, support, and motion.

Important Facts. — The disease, *rickets*, frequent in early life, is due to want of mineral matter for the bones; on account of which they become soft and easily bent. Children subject to rickets should have plenty of fresh air, sunshine, nourishing food, comfortable clothing, and the best of hygienic care in general. There is danger of causing *bow-legs* by standing children on their feet too soon, *curvature* of the spine is apt to result from sitting too long at a desk or table in an abnormal position. Round

shoulders, small, weak lungs, and spinal diseases are frequent results of improper position of the spinal column. The ligaments, which bind the bones together in a joint, may be strained, twisted, or torn from their attachments. A *sprain* is quite a serious thing and requires careful attention and this should not be delayed.

"Fractures are usually met with when the person is dressed. Therefore, unless there is bleeding, or something to call for immediate exposure and examination of the damaged part, do not be in a hurry to remove the clothes. If the arm be hurt, extemporize a sling from a neck-handkerchief or some other article of dress, and support the arm from elbow to wrist, tying the ends of the handkerchief in a knot over the coat-collar behind. If the thigh or leg be in pain, fasten the injured limb to its fellow by a cravat bandage or two, and take care that they lie side by side, and on the same level; or fasten outside the clothes some temporary support — a piece or two of straight stick, with a bandage — and then remove the sufferer quietly and carefully to some house near at hand. If medical aid be available, send for it without any delay; and be careful, if in the country, and at some distance from the doctor's house, to forward a clear statement as to the apparent nature of the accident, which

limb is hurt, and where and how it happened. Let this statement, too, be in writing, if possible. It may well happen, however, that skilled assistance cannot be had, and in this case the patient should be undressed quietly and cautiously. It will be far better to slit up the dress on the arm or leg with a pair of scissors than to pull it off; but however the covering of the injury may be managed, it must be done very slowly and gently, and the limb should be supported so as to prevent jarring and shaking to the damaged part. It must be carefully kept, too, in a right direction, for otherwise some sharp splinter of bone may penetrate the hitherto unwounded skin."—*First Help in Accidents and Sickness.*

REVIEW QUESTIONS.

1. What is the composition of bones?
2. Contrast bones of a youth with those of an old person as to composition.
3. How do bones ossify?
4. What is the number of bones in the body?
5. Name the principal parts of the head.
6. What are the parts of a tooth?
7. Classify the teeth.
8. State some facts as to the care of the teeth.
9. Describe the spine.
10. Why is not the spinal column made up of a single bone in place of the vertebræ?
11. Why are not all the ribs attached to the sternum?
12. When has the human body greater length than usual?
13. State why this is the case.
14. How does bone differ from cartilage?
15. What are some of the uses of the pelvis?
16. What bones constitute the shoulder?
17. Name the bones of the arm.
18. State some fact about animals in comparison with man.
19. What are the chief uses of cartilage?
20. Give the three great functions of the osseous system.
21. State three facts as to the care of the bones.

BLACKBOARD OUTLINE.

THE SKELETON.

I. The Head — 28 Bones.

1. **The Skull** — 8 Bones.	2. **The Face** — 14 Bones.	3. **The Ear** — 6 Bones.
1 Fron′tal (forehead) 1 Occip′ital (back of head). 2 Pari′etals (side of head). 2 Tem′porals (temples). 1 Sphe′noid (“wedge-shaped”). 1 Eth′moid (“sieve-like”).	2 Na′sals (bridge of nose). 2 Ma′lars (cheeks). 2 Lach′rymals (“tear”). 2 Pal′ates. 2 Tur′binated bones. 2 Upper max′illary bones (jaw). 1 Lower max′illary bone. 1 Vom′er (“plough-share” between nostrils).	2 Mal′leus bones (“mallet”). 2 Incus bones (“anvil”). 2 Sta′pes bones (“stirrup”).

II. The Trunk — 54 Bones.

1. **The Spine** — 26 Bones.	2. **The Chest** — 26 Bones.	3. **The Pelvis** — 2 Bones.
7 Cer′vical ver′tebræ (neck). 12 Dor′sal ver′tebræ 5 Lumbar. 1 Sac′rum (“sacred” — used in sacrifices). 1 Coc′cyx (“cuckoo”).	14 True ribs — 7 on each side. 10 False ribs — 5 on each side. 1 Ster′num (breast bone). 1 Hy′oid (base of tongue).	2 Innomina′ta (hip — the name of one is Innominatum).

III. The Extremities — 124 Bones.

1. **Upper Extremities** 64 Bones.	2. **Lower Extremities** 60 Bones.	
1 Clav′icle (*clavis*, key). 1 Scap′ula (shoulder blade). 1 Hu′merus (arm). 1 Ul′na (forearm — Greek for elbow). 1 Ra′dius (forearm — Latin for spoke). 8 Car′pals (wrist). 5 Met′acar′pals (palm). 14 Phalan′ges (fingers — 3 in each finger 2 in thumb).	1 Fe′mur (thigh). 1 Patel′la (knee-pan) 1 Tib′ia (leg — Latin for “flute”). 1 Fibula (leg — Latin for “pin”). 7 Tar′sals (ankle). 5 Met′atar′sals (instep). 14 Phalanges (toes — 2 in great toe 3 in each other one).	

III.

THE MUSCULAR SYSTEM.

Behold the outward moving frame,
Its living marbles jointed strong
With glistening band and silvery thong,
And linked to reason's guiding reins
By myriad rings in trembling chains,
Each graven with the threaded Zone
Which claims it as the master's own.—Holmes.

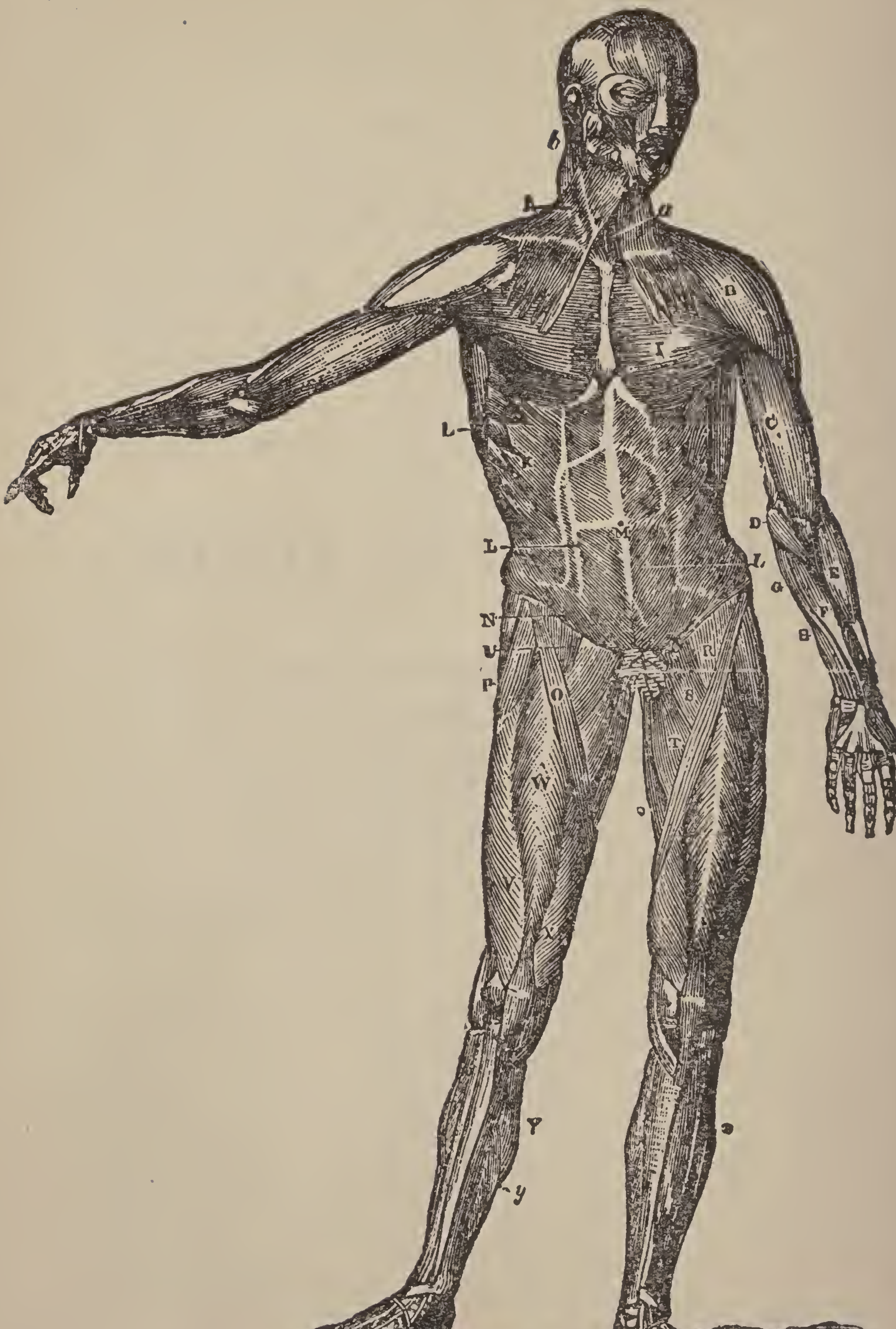


FIG. 13.

MUSCLES OF THE FRONT FIGURE.

A, Platisma Myoides. Broad muscle of the neck. *a*, Sterno-Hyoideus. Muscle between the breast and tongue bones. *b*, Mastoideus. Mastoid muscle. *B*, Deltoides. The muscle covering the shoulder-joint. *C*, Biceps Brachii. Two-headed muscle of the arm. *D*, Pronator Radii Teres. Pronating muscle of the arm. *E*, Supinator Radii Longus. Supinating muscle of the arm. *F*, Flexor Carpi Radialis. Radial flexor of the wrist. *G*, Palmaris Longus. Long bending muscle of the hand. *H*, Flexor Carpiulnaris. Ulnar flexor of the wrist. *I*, Pectoralis Major. Large muscle of the chest. *K*, Obliquus Descendens. Oblique descending muscle. *LL*, Rectus. Straight muscle. *L*, Linea Semilunaris. Semilunar line. *M*, Linea Alba. White line. *N*, Poupart's ligament. Poupart's ligament. *OO*, Sartorius. The "tailor's muscle." *P*, Tensor Vaginæ Femoris. Stretcher of the fascia lata. *U*, Psoas Magnus. Large lumbar muscle. *V*, Vastus Externus. Great external muscle. *W*, Rectus Femoris. Straight femoral muscle. *X*, Vastus Internus. Great internal muscle. *Y*, Gastrocnemius. Muscle of the calf of the leg. *y*, Soleus. A broad flat muscle of the leg. *Z*, Tibialis Anticus. Anterior muscle of the leg.

III. The Muscular System.

1. MUSCLES AND FAT.

Experiment.—Stretch out one arm and let its upper part be grasped by another person. Then slowly bend up the fore-arm; the person will now feel that a portion of the top of the upper arm is swelling; in fact, there is now a compact mass of flesh which was not observably so prominent before, and which relaxes again when the arm is stretched out. Could we remove the skin after the arm is bent up, we would find a mass of red flesh, or muscle, called the *biceps* muscle. Hence, two changes will be discovered:—

a. The muscle *swells.*
b. It becomes *harder.*

The motion of this muscle is, like all motion, the manifestation of a force; in the present case, the force of the will. The flesh, or muscle, is the carrier of this force.

The above experiment shows that muscles produce

motion by means of their *contractility.* This is the first property of muscles.

Contractility is the property of muscular tissue, by virtue of which it shortens itself.

It is in this way that muscles move the bones to which they are attached. The second property of muscles is their *sensibility.* As a general thing, healthy muscles are not very sensitive; witness the slight pain caused by a cut in the flesh. Their sensibility consists in this, that they can communicate to the mind the state and condition in which they are. If, for example, a muscle is fatigued, or in a state of cramp, we immediately become conscious of it. Hence, sensibility is that property of muscular tissue, by virtue of which it informs the mind of the condition, or state, of the tissue.

About ten minutes after death the muscles of the body pass, spontaneously, into a state of contraction very nearly like that which takes place during life. This produces a general stiffness of the entire body, and is known as the *rigor mortis*, or *post-mortem rigidity.* This is caused by the coagulation of the protoplasm of the muscle cells.

Fat or Adipose Tissue is an oily concrete substance, consisting of stearine and elaine. It is found

generally immediately under the skin, and in nearly all other portions of the body.

In children, and in some adults, we notice this soft tissue. Its chief uses are the following: —

1st. The fat, which is situated directly beneath the skin, prevents much of the heat of the body from escaping, because fat is a poor conductor of heat or cold.

2d. Fat serves as an elastic packing material in which to wrap delicate structures, such as the palm of the hand and the soles of the feet.

3d. It serves as a store of combustible matter — that is, it may be burnt up in the system, and thus become a source of heat to the body.*

4th. It serves to fill the cavities of the long bones. It is then called marrow.

5th. It gives, together with the muscles, the full, round appearance, so necessary to beauty.

The Structure of the Muscles.— *The muscles* are the organs of motion in the body, and are composed of lean meat, or red flesh. Roughly estimated there are about 532 in the human body, each performing a

* Fat seems to be a sort of storage-battery to the bodily machine. A familiar example of the wise foresight of the Creator in storing the body with fat is seen in the case of severe illness, at which time the fat takes the place of food.

distinct and separate office, yet all combined into a perfect whole. They compose the greater part of the flesh of the body and extremities. They are the active agents in the movement of the parts of the body upon each other, and in the movement of the body from place to place.

Experiment.— Take a piece of lean meat, and soak it in water, washing it thoroughly. This process removes the blood; then the stringy, fibrous-like structure of the muscles can be seen. Every-one has observed how lean meat separates into *rolls* in the case of boiled corn-beef. By the use of the microscope, it is further made clear that the muscles are composed of *fibres* in bundles (called fasciculi), each bundle containing an average of about 150 fibres. These fibres are further composed of other *fibres* called *ultimate fibres*, and are about $\frac{1}{450}$ of inch in diameter, having a polygonal form. These ultimate fibres, in turn, are made up of still smaller filaments, called *fibrils*, which have an average diameter of $\frac{1}{10000}$ of an inch, and which contain about 700 to each ultimate fibre. Each fibril is composed of a string of small cells, or discs. A string with a large number of flat buttons strung upon it, would give a clear idea of a fibril highly magnified. These lines of contact of the buttons

would represent the transverse stripes (striæ), peculiar to muscles under the influence of the *will.* Other fibrils have not this striation.

Description of striped muscle, magnified.

1. Longitudinal cleavage.
2. Transverse cleavage.
3. A disc partially separated from two fragments of muscle.
4. Another disc, or cell, nearly detached.
5. A magnified disc.
6. Fibrillæ separated.
7, 8. Fibrillæ more highly magnified, showing the discs, or cells.

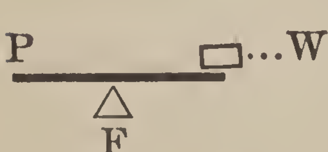
Striped muscle, magnified.
FIG. 14.

The Muscles are Wrapped in a tissue which is found in nearly all parts of the body; it envelops the muscles, it coats the bones and cartilages, and thus connects the different portions of the human body with one another. According to its different uses, it varies greatly in character, being at times soft and tender, at other times very dense and strong, as *e. g.* in the tendons. The fasciculi *

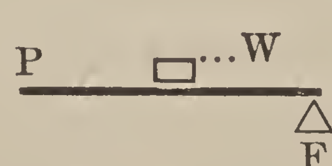
* The bundles, or fasciculi, are united to form larger bundles, and these in turn to form others. Knowing the effect of the small strands in a rope, one can appreciate the strength of the muscular tissue.

and ultimate fibres are invested with a thin membranous-like sheath of *tissue* of a cellular nature. It is called *connective* tissue. The fibrils have no such covering.

Attachments and Tendons.—A *lever* is a stiff bar made to turn on a point, by means of which power is made to do work. The points necessary to apply this power are: 1. The power to be applied; 2. The point of support, or fulcrum; 3. The load to be lifted, or weight; all of which are respectively represented by *P*, *F*, and *W*. These points may be used in three different ways termed the *three classes of levers*. For example, the following illustrations are given:—



FIRST CLASS.



SECOND CLASS.

THIRD CLASS.

Every motion of either the body or its parts may be classed under one of the above kinds of levers.

Experiment.— Straighten the arm and extend it horizontally; place a five-pound weight on the hand. To uphold this weight a muscular effort, or force, of

about 100 pounds is required, to say nothing of the effort to sustain the weight of the arm itself.

Before investigating this phenomenon, the young student should be reminded that the human arm is a lever with its point of support or fulcrum, at the point *o* (Fig. 15) in the shoulder-joint; and that, in virtue of this joint being a ball-and-socket joint (Fig. 15), the arm enjoys motion in a variety of direc-

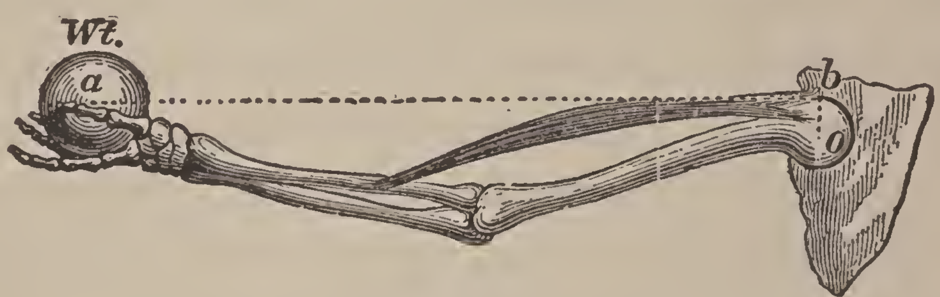


FIG. 15.

tions; and that all these motions are exerted by strongly-developed muscles, extending from the shoulder-blade, clavicle, and thorax to the upper arm, to which they are attached (page 65, Fig. 17).

The weight (Fig. 15) is supported by a shoulder-muscle, through which the power is exerted at the point *b*. Joining the points *o*, *b* and *a* (the weight) by straight lines, a bent lever, *o b a*, with fulcrum at *o*, is formed. The weight evidently operates at the end of the long lever-arm, *o b*, while the muscular power at *b* operates only by the short lever-arm, *o b*. The ratio of the two lever-arms is about as 20 to 1. This explains why the five-pound weight, at the end

of the long arm, acts with a momentum of nearly $5 \times 20 = 100$ pounds; and why the strong shoulder-muscle at the end of *o b*, in order to balance this momentum, must pull upward with a force of (nearly) $100 \times 1 = 100$ pounds. It also accounts for the fact, known to every one, that it requires exertion to hold the arm extended, even without any additional weight in the hand.

The strong shoulder-muscle here mentioned is omitted in Fig. 15 because it would prevent *o b* from being seen. This muscle is the chief but not exclusive supporter of the weight of the ball and that of the extended horizontal arm; in this it is assisted by other muscles, among which is the biceps — the muscle visible in Fig. 15.

The lever, *o b a*, is a lever of the third class, the power being applied between the fulcrum and the weight. A pair of tongs with which to lift lumps of coal is also a lever of the third class. If, now, with a little imagination, we compare the point where the tongs are riveted together with the point below each ear where the jaws come together; and if, furthermore, we imagine each half row of teeth to be a lever similar to one of the levers of the tongs, then half of the upper jaw, with its lower half attached, forms a pair of levers like a pair of tongs. The farther to the rear the

resistance to be overcome by the teeth be placed — that is, the nearer to the fulcrum — the shorter do we make the lever-arm at the end of which the weight or resistance operates, and the less muscular effort is required. It follows, then, that the jaws exert the greatest force between the hindmost molars. Toward the front part of the jaw the teeth lose their grinding power, and it is a wise provision of nature that the front teeth, having but small capacity otherwise, possess a knife-shaped form.

FIG. 16.

The attachments of some of the most important Muscles which keep the Body in the erect Posture.

I, the muscles of the calf; II, those of the back of the thigh; III, those of the spine. These tend to keep the body from falling forward. 1, the muscles of the front of the leg; 2, those of the front of the thigh; 3, those of the front of the abdomen; 4, 5, those of the front of the neck. These tend to keep the body from falling backwards. The arrows indicate the direction of action of the muscles, the foot being fixed. — *Cyclopedia of Valuable Receipts.*

Standing.—When the center of gravity of a body is supported, the entire body is supported.

The center of gravity in the human body lies in the abdomen. In order that a person may stand erect, therefore, the center of gravity must be supported by the legs. This requires work on the part of all the muscles below the trunk. The amount of this work is very great; this is proved — (1) by the difficulty which a little child experiences in learning to stand erect; (2) by the necessity which the adult experiences while standing, of frequently shifting the center of gravity, throwing it alternately over one limb, so as to allow the other to rest for a short time.

Walking.— This act comprises:—

(1) *The lifting of the body.* This is accomplished by lifting the leg; that is, by increasing the distance between the toes and the center of gravity. During this action, one leg supports the entire weight of the body; the other leg having at the same time no load to carry, swings freely forward, after the manner of a pendulum.

(2) *The forward motion of the body*, and its subsequent downward motion as the foot of the other leg is planted on the ground.

(3) *The forward swinging of the leg.* The other leg now bears the weight of the body, while the first

swings freely forward. This mechanical forward swinging requires scarcely any muscular exertion; hence it affords alternate rest to each limb.

Although the entire weight of the body is carried alternately by one foot, yet an hour's walk is less fatiguing than to stand still for an hour, because, in walking, each limb enjoys alternate rest.

Leaping is a combination of two essentially different motions: *First, the body is lifted by the action of the muscles;* of course, there must be a support under foot. *Next, the feet separate from the ground and the body rises;* gravity stops its upward motion and pulls it down again. Let us recall the above example. The first motion, viz., the lifting of the body, is effected by muscular action. It has a limited range, perhaps no more than one-half foot. Now the entire work, as we have seen, amounts to 300 footpounds, and is carried on by a muscular action through one-half foot of space. Therefore, the muscular action, that is, the entire pressure of the feet against the ground, while the body is moving upward one-half foot, in order to produce 300 footpounds of work, must be equal to 600 pounds, for $600 \times \frac{1}{2} = 300$. In order that a person may be able to produce so great a pressure through the one-half foot of space, he must first assume a stooping position. It is the muscular

effort required to produce this great pressure that makes the task so arduous.

The Muscles of the Head and Trunk perform no such intense labor as those of the limbs; hence, they are less substantial. The roof of the skull has no muscles proper, but a tendinous cap, or *helmet*, underlying the hairy skin; it may be moved by muscles in the front and rear portion of the head. The muscles of the eye are of a very delicate structure, and so arranged as to roll the eye-ball, move it slightly forward and backward, and to raise and lower the eye-lids. The tongue, the interior of the mouth, the throat, in fine, all the parts of the body, have suitable layers or strings of muscles in order to produce motion, to hold the limbs in position, and, in general, to protect the skeleton. The entire number of external muscles may be set down at two hundred and forty pairs. (Fig. 13).

The Heart is a muscle which by its motion, propels the blood through the body. At every contraction of the ventricles a charge of about six ounces of blood is driven into the arteries. The great velocity imparted to the blood, and the fact that during life the motions of the heart are carried on in never-ceasing successions — the heart, like the lungs,

never rests while the vital processes are in function — render it, beyond doubt, that the heart incessantly performs an enormous amount of work.

Muscles Remain Contracted only for a short period. They soon relax, and during relaxation their previous strength is regained. In walking, the muscles are constantly changing from contraction to relaxation, while the erect position of the body requires the activity of all the muscles; for those muscles which are situated in front prevent the body from inclining backward, while those behind prevent the body from bending forward. The muscles upon the sides of the body act in a similar manner. This explains why to stand erect and motionless for a given time is much more tiresome than to move about during an equal length of time. We gather new strength when we rest or sleep; complete rest is found only in a lying position.

When a Force Performs Work, the work is always a motion of some kind or other. The force of the will or mind, when imparted to a muscle, causes the muscle to perform work which, for the greater part, consists of motion. Motions produced by the human body are utilized mainly because of their being converted into force when they are suddenly arrested.

The blacksmith, having imparted motion to his hammer by lifting it, changes this motion into force when the hammer strikes the iron upon the anvil. If the weight of the hammer = 3 pounds, and the height of its descent = 4 feet, the work performed by the person is $3 \times 4 = 12$ footpounds. (A footpound is a pound lifted through one foot of space against gravity.) But this does not tell us anything about the quantity of muscular exertion. Perhaps the following instance will make it clearer: If an adult weighing 150 pounds wishes to leap two feet high, the amount of work $= 2 \times 150 = 300$ footpounds. On an inclined plane, or stairway of gentle slope, this amount of work is performed easily in one or more seconds. But to do it by jumping seems to require a greater effort, although the amount of work performed remains the same.

The experience of a long period of years has shown, beyond doubt, that the mechanical power of the human body is used to best advantage by both employer and employee when the work is done regularly and continuously, not in separate, fitful exertions. Man's forces must not be exhausted further than rest and food can replace them day by day. In utilizing our physical forces, therefore, certain limits must be observed, a limit of exertion as well as a limit of time. Any deviation has always been fol-

lowed by a deterioration in the value of the work done.

From the preceding it would appear that a large amount of muscular force exerted by a human being during the day is wasted; but we must remind ourselves that much of the force apparently lost is realized as a gain of time, a convenience of direction, and as a greater range of motion.

Tendons. — It should be stated here that nearly all muscles terminate at their ends, where they are attached to bones, in sinewy, inelastic cords, called *tendons*. Tendons form the connecting link between muscle and bone, just as ligaments between bone and bone. When the extremity of the bones presents a broad surface for attachment, the tendon is broad accordingly; but should the place of attachment be small,

Hand, arm, and shoulder, showing tendons.

FIG. 17

the tendon accommodates itself to the circumstances. The tendons combine to give strength and beauty to the limbs, which, without the compactness of these inelastic cords, would be clumsy and unwieldly. The tendons* and muscles unite firmly and smoothly. The tendons are composed of dense areolar tissue.

LOWER PORTION OF THE LEG.

FIG. 18.

The largest tendon in the body is the tendon of Achilles, in the heel. The strength of the tendons is wonderful. It is said that the tendon of Achilles will hold up a 1000-pound weight.

The Kinds of Muscles.—There are two kinds of muscles, distinguished by their structure and mode of action: *first*, the *voluntary* muscles, as the biceps and nearly all the muscles used for moving bones. The action of voluntary muscles is, to a large extent, controlled by the will. *Second*, the *involuntary* muscles, as

* The arrangement of the tendons in moving the fingers may be nicely shown by taking the leg of a chicken, one tendon moving one toe, and another tendon, another.

in the trachea, the bronchi, and the digestive canal. The non-striped, or involuntary muscles, are found in the walls of the hollow viscera; that is, the stomach, intestines, bladder, etc., as well as the walls of the air tubes, gland ducts, blood and lymph vessels, the skin, and mucous membranes. These muscles are beyond the control of the will. Thus, whether we will or not, the process of respiration goes on day and night. The roughness of skin, called *goose skin*, is caused by the action of involuntary muscular fibres in the skin. It is usually the result of cold, electricity, or sudden mental impressions. Some muscles are both voluntary and involuntary, as those of the eye-lid, while the muscles controlling respiration are voluntary only to a certain extent.

The voluntary muscles may be classed as animal, or striated (striped), while the *involuntary* may be termed organic, or unstriated (non-striped). The striped structure was discussed in a former paragraph. One marked exception to the rule, *that all striated muscles are voluntary*, is the heart, which is an *involuntary* muscle, although transversely striped. Notwithstanding that the heart is purely involuntary in its action, there have been cases recorded of persons who could control the beating of their hearts. However, such cases are rare.

Muscles are also Classed according to their form, as *radiate*, *fusiform*, *penniform*, *orbicular*, *ribbon-like* and *cord-like*.

The Arrangement of the muscles is very simple, they being arranged in pairs. The two sides of the body are alike. For every muscle producing a certain motion, there is another muscle producing an opposite motion. This can be easily tested by alternately raising and lowering the fore-arm. This arrangement admits of a multiplicity of movements. The variety of movements in the case of the human hand is inconceivable. With the wonderful disposition of the 532 or more muscles of the body, man becomes God-like in his physical powers. In muscles there is as much diversity in the size as there is in the variety of motions. The longest muscle, *sartorius*, is over eighteen inches in length, while the smallest is the *stapedius*, a muscle of the ear, which is only one-sixth of an inch in length.

2. THE USES AND FUNCTIONS OF THE MUSCLES.

The Muscles not only add to the beauty of form and outline of the body, but they make possible its vast number of motions. They are the active agents of motion as well as locomotion. To appre-

ciate the effect of the muscles with other flesh tissue intact upon the frame-work of the body, examine that same frame-work without the soft tissue; that is, the human *skeleton*, the very name of which almost strikes terror. To appreciate the variety and beauty of movements, made possible by the intricate muscular arrangement, notice the graceful dancer whirling away through the waltz; the hands of the skillful performer upon a musical instrument, bringing forth sweet melody; or the rapid and delicate touches by which the artist portrays a living landscape to your wondering vision! Whether it be the laborer wielding his heavy sledge, or the prima donna trilling the variations of a sonata, the same unerring laws must be followed!

The discussion of the motion and use of each muscle belongs to the higher study of this subject, yet it is interesting to know how the *biceps* raises the fore-arm; how the *gastrocnemius*, *plantaris*, and *soleus*, of the back part of the leg, assist in walking, and standing upon tip-toe; how the famous *sartorius* assists the tailor in throwing one leg across the other; how the great *psoas* muscle bends the thigh upon, or towards the body; how the *intercostals* raise the ribs; how the *diaphragm* enlarges the chest cavity, and how the *masseter* and *temporal* move the lower jaw. When we consider that there are

about 532 muscles, we can imagine what a complex subject the mastery of all their uses and motions would be. And yet how necessary to man's highest development are all these movements! However, a few suggestions on muscular development will be helpful.

Muscular Development and Exercise. — All living things must do, in order to remain in health, what the Creator intended them to do. The fish must swim, the bird fly; so, also, must man, who is the highest of the animal creation, perform many complex duties that he may fulfill the laws of his being. His limbs, stomach, nerves, and mind must attend to their appointed ends.

Observation.— Tie an arm to your side, and in a few months it will waste away to skin and bone. In the same way the brain from a lack of use will become incapable of strong, healthy action.

Exercise makes the muscle grow larger, darker, and more solid. Notice the huge strong muscles of the blacksmith or prize-fighter, as compared with the soft, pale, flabby tissue of the clerk who sits for hours with neither manual labor nor exercise.

Many occupations tend to give all the parts of the

body their necessary use. Farming is mentioned as one of these, and such occupations tend to long, happy lives.

A rule of exercise should be: *Let the kind of exercise be selected that will bring into use muscles that were not used while at our accustomed employment.* If we sit at our work, let our exercise in recreation be walking, riding, etc., while if we use our lower limbs much in our calling, let the upper part of the body be correspondingly trained. Plenty of muscular exercise should be followed by mental training, and *vice versa.*

Another law in exercise should be: *Always stop before you feel tired.* Excessive or violent exercise is very unwise and injurious. Long-continued or violent exercise often produces death.

No school, of whatever kind, is now complete without a systematic, thorough, careful course in physical training. Half the energy of pupils is wasted by over-study and under-exercise. How necessary to keep the house — the human body — as well as the inhabitant — the mind — in good condition!

Why Exercise Should Be Taken.— 1. The immediate effect is strengthening and enlarging the muscles, which form such a large proportion of the body.

2. It causes the blood to flow more freely through the muscles and incites the lymphatics to action, thus making them more active, and refreshing the whole body, stimulating all the organs.

3. Exercise develops the whole body harmoniously, so that each part may bear the strain necessary to allow every other part to do its proper work. Nothing is more beautiful than the fully-developed, well rounded, elastic, hardy human form — the crowning glory of the Creator's work.

4. *Exercise* prevents crooked limbs, spine curvatures, weakness, sickness, mental disorders, while it vastly increases the individual's capacity for labor.

5. It frees the body from waste matter.

Kinds of Exercise.— There are so many varieties of beneficial forms of exercise that it seems needless to name any. Yet, we mention these: Walking, riding, rowing, bicycling, tennis, croquet, etc. This may be taken as a guide in selecting the kind, *that it be an active, outside, general exercise, pleasing to the one who takes it.* Inside exercise is better than none.

How Contraction Takes Place.— Some physiologists have taught that the contraction of the muscle is due to a peculiar position of the fibrils, but it is now definitely determined that it is due to a

state of the little cells, or discs. By the use of the microscope it has been learned that, in a state of contraction, each little cell thus affected shortens itself in the direction of the fibres, while at rest the cell has its greatest diameter parallel to the direction of the fibre. This contraction begins at one end of the fibre, and passes step by step to the other end, thus exercising only a part at one time. How the energy (that passes along the nerves to secure the action) does its work, is a mystery.

Muscular fibre has the property — *Contractility* — of shortening itself when a stimulus is applied. These stimuli have been mentioned elsewhere. The irritability and tonicity* of muscular fibre are dependent upon nervous or vital force. If the influence of either nervous or vital energy be cut off, the irritability and tonicity will cease in a short time.

Muscular Contraction is very rapid. The heart pulsations in children have been known to be nearly two hundred per minute, while persons can pro-

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* Some writers upon the subject of physiology name the above property of muscles, which they call *tonicity*. *Tonicity* is a constant strain of the muscular fibre. It is this property which pulls a cut, or gash, wide apart. It makes the muscles ready for action. It might be termed the life of the muscle.

nounce eight times that many letters per minute. The number of contractions to produce a musical tone must reach a very large number per second.

The Strength of muscular fibre is beyond comprehension. Men have been able to take in their teeth a barrel of flour — 196 pounds in weight — by the chime, or ends of the staves, and throw it over their heads. You remember Milo of Crete, who killed an ox with his fist, and then carried the animal 200 yards. Milo saved the celebrated philosopher and teacher, Pythagoras, by supporting a fallen roof until they both could escape.

The Muscular Sense is the sensation of weight which we feel in lifting a body and which we compare with similar sensations in lifting another body. This sensation may be highly cultivated. Bank tellers readily detect a spurious coin by this power. This sense is brought into use in many of the movements of the body, and is very helpful to man.

Important Facts — *Muscles need rest.* — The period of rest must be sufficient to enable the muscles to regain their tonicity. Constant moving allows the muscles to rest. However, sleep is the only rest which will restore vigor and life to the muscles.

REVIEW QUESTIONS.

1. What is the biceps muscle? What is the muscle usually called?

2. What two changes take place when the muscles act?

3. What is motion? Define contractility.

4. What is sensibility? What is *rigor mortis?*

5. How soon after death does it set in? What causes it?

6. What is fat, or adipose tissue? At what stage in life is fat generally found?

7. What effect has fat upon the bodily temperature in winter?

8. Name several uses of fat. What is meant by storage-battery?

9. Define muscle. How many muscles in the body?

10. What is wonderful about the uses of the muscles?

11. Explain how the structure of muscular tissue may be shown.

12. Explain the relation of ultimate fibre to *fibrils.*

13. Describe the form and thickness of ultimate fibres.

14. Also, tell all you can about the filaments, or fibrils.

15. What are fasciculi? What makes a muscle so strong?

16. Explain how the ultimate fibres and fasciculi are protected. What is the covering called?

17. What is the structure of a fibril? How illustrated?

18. Define lever. What points are necessary in the lever?

19. Explain by means of a stick and brick the three classes of levers.

20. Name the kind of lever, and locate the fulcrum, power, and weight in each: 1. Standing on tip-toe; 2. Bending the trunk backwards; 3. Masticating food; 4. Raising the leg forward; 5.

Bending the lower leg backwards; 6. Lifting an object with the toe. Give other examples.

21. Give several uses of the muscles.

22. How may one appreciate the benefit of the muscles as a clothing for the bones?

23. How may we appreciate their variety of movements?

24. In what way are muscles subject to law?

25. Why is it not practicable to study the motion and use of each muscle?

26. Name several prominent muscles, locating them.

27. What has been advanced by some physiologists as the cause of muscular contraction?

28. What is the true theory of this? Explain it.

29. Define contractility. Describe another property of muscles.

30. Upon what does irritability and tonicity depend?

31. Explain how rapid muscular contraction is.

32. Give some examples of the strength of muscular fibre.

33. What do you know of Milo of Crete? Of Pythagoras?

34. Explain what is meant by muscular sense. Give some examples of its benefits or uses.

35. What relation do you observe between living things and "their appointed end?"

36. State different effects of exercise upon muscular tissue.

37. Name some occupations that tend to give work to all the muscles.

38. Give the rules on exercising.

39. What should every school have for this purpose?

40. State the effects of exercise upon the muscles.

41. Name several kinds of exercise.

42. How should one rest? Should exercise be regular?

BLACKBOARD OUTLINE.

THE MUSCLES.

1. The Muscles and Fat.

- **Muscles.**
  - a. Experiment and Definition.
  - b. Properties.
    - Contractility.
      - Enlarges.
      - Makes Firmer.
    - Sensibility, or Irritability.
    - Tonicity.
    - Rigor Mortis.
- FAT.
  - a. Definition. Location.
  - b. Uses.
    - Keeps the Heat in the Body.
    - Protects the Delicate Structures.
    - As a Storage-battery of Heat.
    - Fills the Bone Cavities.
    - Adds to Beauty.
- **The Structure of Muscles.**
  - a. General Facts.
    - Number.
    - Greater part of the Body.
    - Agents of Movements.
  - b. Tissue.
    - Rolls.
    - Fasciculi.
    - Ultimate Fibre.
    - Fibrils.
    - How Related, and How Illustrated.
- **The Muscles are Wrapped.**
  - a. Connective Tissue.
    - Skin.
    - Mucous Membrane.
    - Fascia.
- **Attachments and Tendons.**
  - a. Classes of Levers
    - First.
    - Second.
    - Third.
  - b. Experiments.
  - c. Movements.................
    - Standing.
      - Center of Gravity.
      - Muscles at the Back.
      - " in Front.
    - Walking.
    - Leaping.
      - Lifting of the Body.
      - Forward Motion of the Body.
      - Swinging of the Leg.
    - Head and Trunk.
    - Heart.
  - d. Muscles Remain Contracted.
  - e. When a Force Performs Work.
- **Tendons.**
  - a. Definition and Attachment.
  - b. Uses and Composition.
- **The Kinds of Muscles**
  - a. According to Structure and Appearance....
    - Voluntary — Animal, or Striated.
    - Involuntary — Organic, or Unstriated.
  - b. According to Form....
    - Radiate.
    - Fusiform.
    - Penniform.
    - Orbicular.
    - Ribbon-like.
    - Cord-like.
- **The Arrangement — IN PAIRS.**

2. The Uses and Functions.

- a. Uses.
  - To produce Motion.
  - To hold the Limbs in Place.
  - To protect the Bones and Delicate Organs.
  - To add to the Beauty of Form.
- b. Functions.
  - Development and Exercise
    - Their "appointed end."
    - Experiment.
    - Exercise — Occupations.
    - Rules of Exercise.
    - Gymnasia.
  - How Contraction Takes Place....................
    - Theory.
    - Stimuli.
    - Rapidity of —
    - Strength of.
    - The Muscular Sense.
    - Why Exercise.

3. Important Facts.

IV.

THE SKIN, HAIR, AND NAILS.

Behold the grasses of the field! the fishes of the sea! the fowls of the air! Infinite Wisdom hath enveloped them in their own appropriate coverings, conserving destined ends!

So man, "a little lower than the angels," hath been clothed in a wondrous garment, guarding the numberless doorways of the busy laboratories within, firm and enduring as the magic cloak of old, flexible and elastic as the far-famed product of India's priceless tree, living yet dead, dead yet living, soft and delicate to the touch, and beautiful to the eye. All this is the human skin, the highway to the soul of man, whom God hath thus adorned with rich raiment and a crown of glory.— Luckey.

IV. The Skin, Hair, and Nails.

1. **Introduction.**—Clothing not only protects the body, by keeping out the heat and cold, but it also enables us to come in contact with things around without injury or inconvenience. In the same manner, the skin protects the soft, sensitive flesh from contact without. Were the skin removed from the body, the contact of the bare flesh with even the atmosphere would be agonizing. Hence, the skin is not only a soft, pliable, firm, and elastic covering for the body, but it is an ornament as well, pleasing to the eye. These are only a few of the duties of this most important element of the system, as the skin is the channel through which the body daily relieves itself of a large amount of effete matter, adding greatly to health and comfort.

2. **Structure of the Skin.**— *The skin* is the external covering of the body. It consists of two layers — the outside skin, the *epidermis*, or *cuticle*, also called *scarf-skin*, and the inner one or *dermis*, called *cutis vera*, true skin.

The Epidermis contains coloring matter, which gives rise to shades of tint in the skin of both individuals and races. The coloring is developed by exposure to the sun. The more the skin is subjected to friction and pressure, the more does it grow — that is, the more does it become thick and horny.

The epidermis serves to protect the sensitive lower skin, or dermis, and to moderate the evaporation of fluid from the blood vessels.

These two layers, *cuticle* and *cutis vera*, are very closely united, yet their separation is clearly shown when a blister is produced upon any part of the body. A watery fluid gathers under the *epidermis*, which is shown to be a thin, white membrane, devoid of feeling and blood. It is made up of round-like cells, which become flattened at the upper surface, and drop off in scales. This is exemplified in the case of the scalp, whose cast-off scales are called *dandruff*. The epidermis renews itself upon the under surface. This part of the skin varies in thickness on different parts of the body, and bears the same relation to the inner skin, *cutis vera*, that the external bark bears to the inner, living bark, of the tree. The cuticle upon the face is only about 1000th of an inch in thickness, while upon the soles of feet, it reaches 1-12th of an inch. In composition, the

epidermis is albumen — the same as the white of an egg.

The Dermis, or *cutis vera*, lies below the surface, is the true skin, and invests the arteries, veins, lymphatics, nerves, sweat and oil glands, being the origin and support of the *epidermis*. It is firm and elastic, these properties being due to the presence of muscular fibre. Its extreme sensitiveness and vitality may be ascertained by inserting a fine needle into the tissue. This part of the skin is made up of white and yellow fibrous tissue. The upper surface of the dermis is covered with little protuberances, called *papillæ*, which contain these nerves and blood-vessels.

The lower part of the dermis contains the sweat glands, whose outlets through the epidermis are called *pores*. Here lie also the oil glands.

Glands.— The secretions of the skin consist of two different fluids; one oily, the other watery. The oily one is secreted mostly in the scalp and the face, where the skin is largely supplied with hair. The other is called *perspiration*, or *sweat*, the two terms being habitually taken synonymously, although there is this difference between them: Per-

spiration is an insensible excretion, which evaporates on the skin; sweat is a sensible secretion, composed of the same fluid as the other, but appearing on the skin in the form of drops. The passage of these fluids is affected by a multitude of fine canals, or pores (Fig. 19) in the skin. Perfect health requires cleanliness, so that the activity of the pores shall not be impeded.

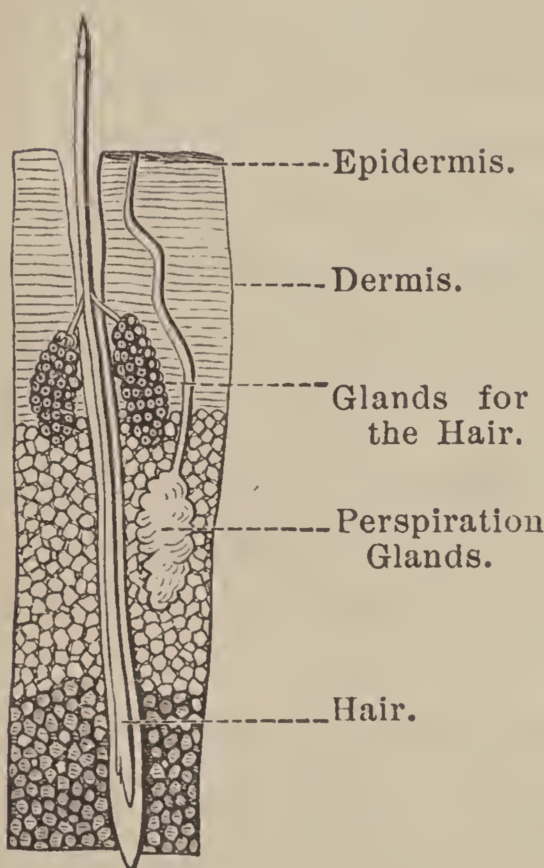

FIG. 19.
Sectional View of the Human Skin, Highly Magnified.

The quantity of water lost by transpiration depends, like all evaporation in the open air, upon the temperature, the saturation, and the stillness of the atmosphere. In hot weather the quantity of excretion from the skin is greater than in cold. When the atmosphere is fully saturated with watery vapor, perspiration does not evaporate; and the consequence is an almost insufferable sensation of heat. The same holds true when, owing to the absence of currents of air, the watery vapors of

perspiration remain around the person instead of being constantly displaced by fresh; that is, less saturated air.

Connective Tissue.— A piece of fresh animal skin, put into water, will swell up without dissolving. If now the skin be boiled in the water for several hours, most of it will dissolve, and on allowing the liquid to cool, a gelatinous substance is obtained. When dried, this forms the well-known *glue*. Nearly all connective tissue yields the same result if treated in a like manner.

3. **Hair and Nails.** — These are forms of the epidermis.

The Hair and Nails are peculiar forms of the epidermis. The latter are composed of horny scales and cells, closely packed together. The root of a hair, together with the root-sheath in which it is imbedded, may be seen when a hair is pulled out.

The Hair not only protects the head from heat and cold, but it is a safeguard against injury, as well as being an ornament. A hair consists of *root*, *shaft*, and *point*. Hair is found on nearly all parts of the body, excepting the palms of the hand and the

soles of the feet. In composition a hair has three parts: an *epidermis*, a *fibrous* part, and a *marrow-like* center. The epidermis is in scales, overlapping one another like the shingles on a roof. Each hair is formed upon the apex of a papilla. The color is thought to be due to the presence of iron in the hair. Hair is very elastic, stretching nearly one-fifth its length. It is dry and harsh or moist, according to the condition of the skin. The hair grows rapidly, faster by day than by night, and in summer than in winter.*

The Nails are very useful and ornamental. By means of them our fingers and toes are protected and we can perform many little motions that otherwise would be impossible. Besides they add so much to the beauty of the fingers and toes. The nail grows from an underfold of the *cuticle*, of which it may be considered a continuation. As the nail grows, it is pushed out, starting from a groove-like root, called the *matrix*. The nails, unlike the hair, have blood-vessels. The Chinese have the

* The number of the hairs varies with the color and portion of the body. In one case there was found on the same surface 147 black hairs, 162 brown, and 182 blonde. On a surface one-fourth of an inch square the same author found on the scalp 293 hairs and on the chin, 39.— *Hitchcock.*

habit of allowing their nails to grow sometimes as long as two inches. A nail will grow its whole length in about 15 weeks, on an average.* The nails should be carefully pared with a sharp knife, but never scraped on top.

Nails grow, like hair, by the constant addition of cells from beneath and behind, which take the place of portions worn away or cut off.

4. **Functions and Hygiene of the Skin, Hair, and Nails.— The Skin** prevents absorption, because the lymphatics terminate in the dermis, this being separated from the external world by the epidermis. It will be readily observed that this arrangement prevents the absorption of injurious liquids brought into contact with the body. However, there is absorption through the skin, and poisonous cosmetics, washes, and hair-

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* "To show the duration of life in one kind of cell, let us turn to the human nail. The latter, growing from a furrow of the skin, is made up of skin-cells. In the depth of the furrow, youth prevails; at the upper margin — which we trim — old age. Berthold proved that a nail-cell lives four months in summer and five in winter. A person dying in his 80th year, has changed his nail 200 times at least — and the nail appeared such an inanimate, unvarying thing! No other cells, we believe, have a life nearly so long as that of the nail."— *Compendium of Histology by Heinrich Frey*.

dyes should be avoided. There have been cases where patients have been saved by absorbing stimulants through the skin, when the proper channels were not in a condition to perform their customary functions.

Again, the impenetrable epidermis, or scarf-skin, prevents excessive perspiration, which would work harm to the system. Owing to a peculiar arrangement of the mouths of the pores, perspiration takes place under a stimulated condition of the body.

By means of the oil glands, the skin is kept soft and pliable, while the hair is rendered flexible and elastic. In consequence of the oily surface of the skin, water will not adhere to it, while the eye and the ear are kept in their proper condition by this oily exudation. Hence, it is seen how important the skin is in the economy of the human body, keeping its balance and regulating its temperature.

The Care of the Skin is most important to health. Were not the skin kept free from impurities, which obstruct the passages of the sweat glands, serious results would follow; such as headache, fever, colds,*

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* All are familiar with the incident which happened at the coronation of one of the Popes about 300 years ago. A little boy was selected to represent an angel, being encased from head to

etc. Hence, nothing but absolute cleanliness and vigor will restore the health of the skin, which may be secured by frequent baths, rubbings, and exposures to the air, of the covering of the body.

Bathing is important. One should, in warm and temperate climates, bathe daily in moderately cool water, with a hot soap-suds bath at least once a week, to remove the scales of the cuticle and the dry, solid portions of the perspiration. Only persons of vigorous health should take these daily baths in cold water. The water should be 75° Fahrenheit. Sea bathing is invigorating not only from the saltness of the water, but from the excitement consequent upon the environments of a well-appointed resort. This paragraph may be appropriately closed with a thought from a well-known scientist. The civilization of a country is high to that degree in which soap is used. May it not be added that this is also true of individuals.

How and When to Bathe.— With the water at the proper temperature, do not remain in the bath too long, as the functions of the skin are partially arrested while bathing. When coming from the

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foot with gold-leaf. In a short time, he fell sick, and every thing but removing the gold-leaf, was done. Of course he died.

bath, vigorously rub the body with a coarse towel until a ruddy glow sets in. This bright, ruddy appearance is a sure test of the good effects of the bath, and is produced by the rushing of the blood from the interior to the surface of the body — an effect called *reaction*. Beware of the dark, blue condition of the skin brought about by bathing in too cold water or remaining in too long. Should such a condition as the last prevail, take a stimulant, exercise vigorously, and clothe the body as quickly as possible. When this effect of the bath prevails, the blood has set toward the heart and interior of the body. Reaction must be secured.

As to the Time of Bathing, select any time except upon an *empty* or a *full* stomach, or when the body is *heated* or *exhausted*. Although nothing is more beneficial to an exhausted person than a hot bath. The habit of taking a cold bath immediately after rising is a good one. It should be taken quickly in order to secure good results. The shock to the nervous system is excellent.

The Body Should Be So Clothed that one feels comfortable, neither too cold nor too warm, in winter and in summer. One's comfort is a

good test of *how much* to wear in the different seasons.*

5. **Important Facts.—The Skin** daily throws off about two pounds of fluid matter, which passes away by means of the sweat glands.

It is interesting to know that these glands are about $\frac{1}{75}$ of an inch in thickness and their tubes about $\frac{1}{400}$ of an inch in diameter, while the length of the tube is about $\frac{1}{4}$ of an inch. There are about 2,500 pores to the square inch on the human body, and the amount of surface upon a person of ordinary size is 2,500 square inches. These tubes in the skin laid end to end would make many miles in length.

It is generally supposed that coloring matter is found in the skin of all persons. However, this is not always the case. Albinoes have no pigment in the epidermis; hence this accounts for their most peculiar appearance.

If the dermis be injured or torn off, the wound will never be covered with skin so permanent.† Yet,

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* Only fools and beggars suffer from the cold; the latter not being able to get sufficient clothes, the others not having the sense to wear them.—*Boérhaave.*

† The skin is not a permanent sheath, but is, as it were, always wearing out and rubbing off, and new skin is always ris-

modern science has reached such a degree of perfection that large pieces of the integument have been transferred from one person to another and made to grow. This process is called *skin-grafting*, and is an ordinary matter among surgeons of the present day.

The Hair is very glossy in health, and grows in length only. The longest and coarsest hair is found upon females. That the hair is not easily affected by external influences is shown in the examples of mummies, thousands of years old, whose hair was still intact when found and even retained its color. A hair will sustain the weight of several ounces.

The Nails grow very slowly. Should a nail be removed by accident, it will be replaced by a new one, provided the root is still uninjured. By filing a small notch at the root of the nail, you can

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ing up from underneath. A snake leaves off his whole skin at once, as we leave off a suit of clothes or a dress, and sometimes we may find his whole cast-off covering turned inside out, just as he crept out of it. In man, generally, we do not notice the dead particles of the skin as it wears off; but where the cuticle is pretty thick, as on the soles of the feet, we can see it peel off in little rolls whenever we wash the feet in hot water. After scarlet fever, too, sometimes the dead skin comes off in great flakes, and from the hands almost like the fingers of a glove.—*Berners.*

observe how fast the nail grows as it nears the end of the finger.

Disorders of the Skin, Hair, and Nails.— Proud Flesh is an unnatural, florid growth of a granulated form, growing in wounds or sores. It is caused by keeping the wound too warm or it may result from a weakened condition of the system.

Treatment.— Powdered calomel will check this growth, which will usually succumb also to powdered burnt alum.

Warts are unnatural growths of the papillæ. They give a repulsive appearance to the hands, or other portions of the body, and should be removed.

Treatment.— Apply to the wart, with a small brush, some *aqua fortis*, being careful not to let it touch anything but the wart. In a few days this application will kill the growth, so that it may be pulled out by the roots.

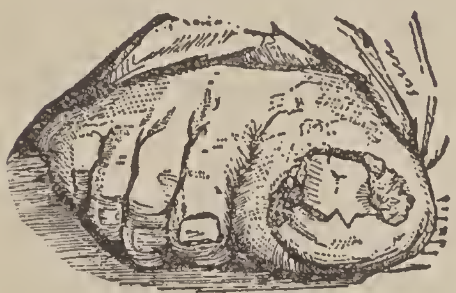
Corns are thickened, calloused portions of the epidermis, caused by constant friction.

Treatment.— Soak the calloused place daily in hot water, and remove the corn or thickened cuticle by paring or rubbing with a pumice-stone.

Continue this, and wear comfortable shoes, in case

of a corn on the foot, and the most obdurate corn may be removed.

An Ingrowing Toe-Nail is a very troublesome thing, and may be a dangerous one.



Ingrowing Toe-Nail.
FIG. 20.

Treatment.— Force lint under the nail to raise it up out of the flesh. This is to be done after the toe has been soaked in hot water to draw out the soreness. Then scrape a furrow down lengthwise through the nail, ending in a little V-shaped notch at the end. Continue this scraping daily, and wear shoes that do not compress the nail. This treatment will cure aggravated cases of ingrowing toe-nail. Proud flesh may be removed by putting on powdered perchloride of iron or dropping hot tallow upon the sore part.

Dandruff (Furfura) is nothing more than scales of the epidermis, which are present on all parts of the body, but more noticeable on the head because of the contrast with the hair in color.

Treatment.— Daily remove the dandruff with a stiff hair-brush. The friction of the head excites the epidermis to healthy action. The hair should

be washed weekly in strong soapsuds and then thoroughly dried. Care must be taken here or cold will result. Little or no oils should be used upon the hair, as the natural oil of the hair is sufficient. Baldness results from sickness, especially fevers. In case of falling out of the hair, wash the head daily in salt water with a little ammonia added, and then rub the head vigorously. Also cut the hair off, if there be a disposition to come out.

Chilblains are an itching, inflammatory condition of the hands, feet, etc. It is caused by a diseased condition of the skin and muscular tissues.

Treatment.—Keeping the parts affected at even temperature, avoiding very great extremes of cold. Do not have the parts affected compressed. At night rub upon the diseased parts a mixture of lard and mustard, thoroughly drying before a fire. Slacked lime, moistened with oil, well rubbed on, is a good remedy.

Eczema, commonly termed Salt Rheum, is an eruption of minute vesicles, closely united and running into one another, so as to form a moist sore.

REVIEW QUESTIONS.

1. Name several uses of the skin.
2. Why would contact with the outside world "be agonizing," were the skin removed?
3. How many layers in the skin? Name them. Give the different names for the outside layer.
4. Where is the coloring matter? What thickens the skin? Where would you be likely to find thickened skin?
5. How is the separation of the dermis and the epidermis shown?
6. Explain the structure of the epidermis. Of the dermis.
7. Explain the cause of dandruff. How does the epidermis grow? Where does it decay?
8. Tell where the skin is thick and where thin.
9. What is the composition of the epidermis?
10. What are invested by the dermis?
11. What makes the dermis firm and elastic?
12. How may its sensibility be determined?
13. What are the offices of the sweat and the oil glands?
14. Explain the difference of the products of the sweat glands.
15. What promotes the activity of the pores?
16. Upon what does the quantity of water lost by transpiration depend?
17. When does the perspiration not evaporate?
18. What commercial product is derived from connective tissue? How is it obtained? Name the kinds of connective tissue.
19. Name two special forms of the skin.

20. Give the uses of each. Explain the structure of each. Give the parts of the hair. Where is hair found?

21. What causes the color of hair? When does it grow most rapidly? Tell something about the number of hairs.

22. How does the nail grow? What is the matrix?

23. What nationality of people have long nails?

24. How long does it require for a nail to grow out?

25. Show the duration of life in one kind of cell, by taking the nail as an example.

26. How should nails be treated? How do they grow?

27. How does the skin prevent absorption?

28. What benefit in this, regarding poisons and stimulants?

29. How is excessive perspiration prevented?

30. What does the oil do for the skin and hair?

31. Why should the skin be kept clean?

32. Relate the incident of the boy at the Pope's coronation.

33. Why should we bathe often? What should the temperature of the water be for ordinary bathing purposes?

34. Explain how and when to bathe.

35. What is reaction? What is opposite to reaction? What must be done when reaction does not set in?

36. What is a good rule for clothing one's self?

37. Tell what Boérhaave says about clothing.

38. How much perspiration daily passes off through the skin?

39. Give the different dimensions of sweat glands, their number, etc.

40. What is skin-grafting? Tell what Berners says of the skin.

41. Tell about the growth of the hair. Its coarseness. How do we know that the hair lasts for a long time?

42. When only will a nail grow? How can you determine the time required for nails to grow out?

43. What is proud flesh? Where is it usually found?

44. What causes proud flesh? Give a mode of treatment.

45. Of what are the warts an unnatural growth?

46. How would you get rid of warts?

47. Give the cause of corns. Tell how to get rid of them.

48. What is an ingrowing toe-nail?

49. Explain a mode of treatment to cure the same. Why is this disorder dangerous?

50. Is dandruff indicative of any danger?

51. What causes the hair to fall out?

52. What should be done in such cases?

53. Define chilblains. How treat the same?

54. What is eczema? Give a general remedy.

BLACKBOARD OUTLINE.

THE SKIN, HAIR, AND NAILS.

1. **Introduction.**
   a. Uses of Skin.
   b. Definition.

2. **Structure of the Skin.**
   a. Epidermis — Cuticle or Scarf-Skin.
   b. Dermis — Cutis Vera, True Skin.
   c. Experiment, Growth, and Thickness.
   d. Glands — { Oil, Sweat, } Their Functions.
   e. Connective Tissue — { Uses. Structure. Functions.

3. **Hair and Nails.**
   a. Definition of Each.
   b. Uses of Each.
   c. Parts of Each.

4. **Functions and Hygiene of Skin, Hair, and Nails.**
   a. Of the Skin.
   b. Of the Hair.
   c. Of the Nails.
   Bathing — { Importance. How to Bathe. When to Bathe.
   Clothing.

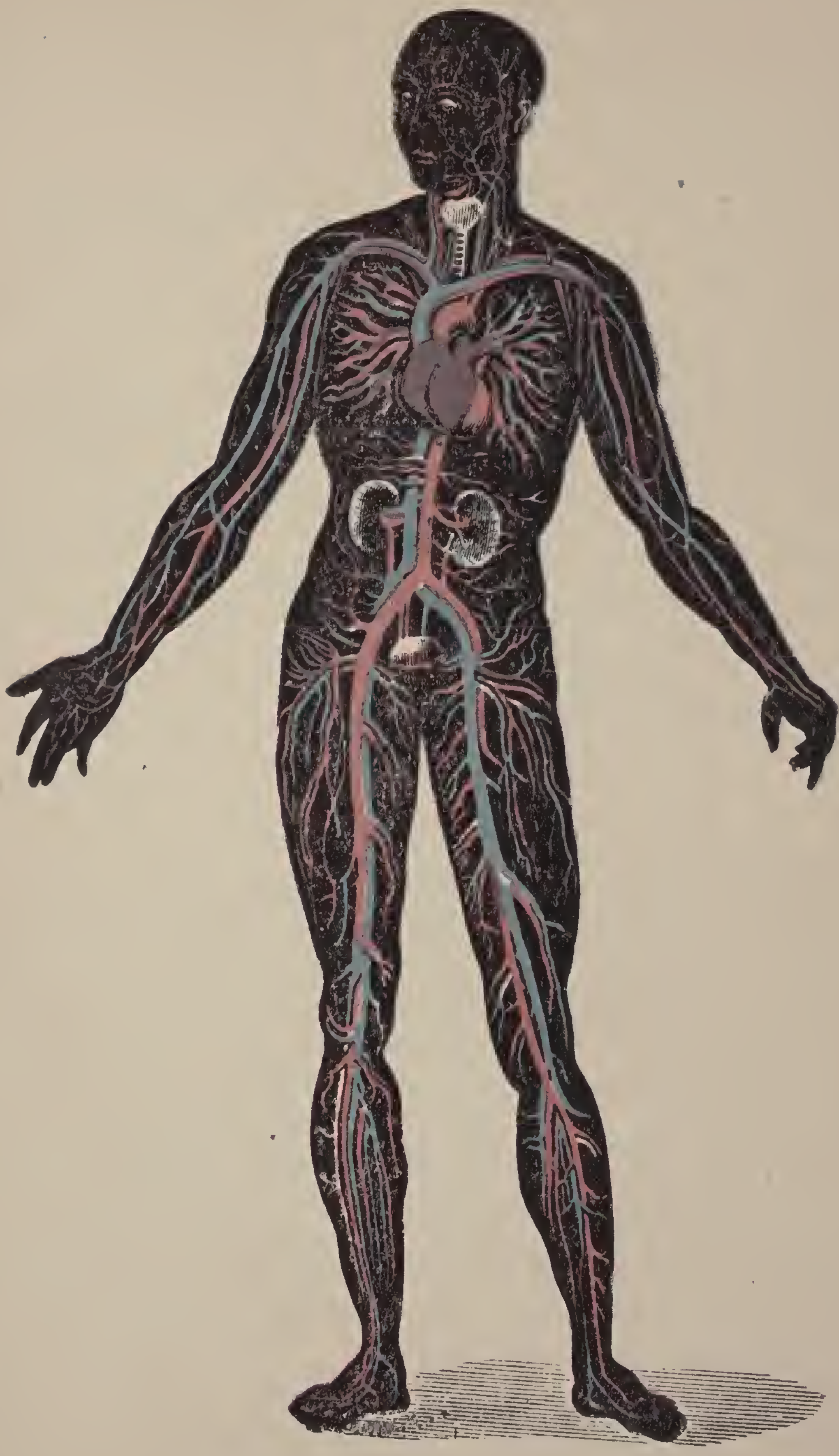
5. **Important Facts.**
   1. Of the Skin.
   2. Of the Hair.
   3. Of the Nails.

6. **Disorders of the Skin, Hair, and Nails, and their Treatment.**
   a. Proud flesh.
   b. Warts.
   c. Corns.
   d. Ingrowing Toe-Nail.
   e. Dandruff.
   f. Chilblains.
   g. Eczema.

V.

THE CIRCULATION.

And red with Nature's flame they start
From the warm fountains of the heart.
No rest that throbbing slave may ask,
Forever quivering o'er his task,
While far and wide a crimson jet
Leaps forth to fill the woven net
Which in unnumbered crossing tides
The flood of burning life divides,
Then, kindling each decaying part,
Creeps back to find the throbbing heart.—Holmes.



CIRCULATION OF THE BLOOD.
(Heart, Lungs, Arteries and Veins.)

V. The Circulation.

1. THE BLOOD.

Experiment. — Allow the blood of an animal to remain quiet in a vessel. In a few minutes it will coagulate, separating into two substances — a solid and a liquid. Stir the solid substance with a stick and you will see collected upon it many thread-like fibres. If the liquid part is boiled till the water in it escapes, the remaining substance will look like white jelly.

The Composition of blood may be studied with much interest in view of this experiment. You will observe that the solid has a dark-red color, and is a sort of jelly. It is called *the clot.* The red color is due to the presence of minute bodies, which are held in suspension in the blood. Besides these red *corpuscles*, the clot contains a white, fibrinous mass, observed on the stick in the experiment — this is called *animal fibrine.* The liquid is called *serum*, which has a yellowish color; but if, by boiling it, we remove its water, it will coagulate to a white jelly, composed of *albumen.* These components of the

blood may be shown in the following form, or outline:—

- Blood.
  - Clot.
    - Blood Corpuscles (red and white).
    - Animal Fibrine.
  - Serum.
    - Water.
    - Albumen.

The red corpuscles of the human blood are cells of different sizes, having the form of discs, each of which has an area of nearly $\frac{1}{1000}$ of a square inch, and a thickness of about $\frac{1}{1000}$ of an inch. They look somewhat like little pearl buttons without the holes in them, only they are red. They possess the remarkable property of adhering together in columns, like rolls of pennies; these rolls, moreover, join at their ends so as to cluster together, forming a sort of network (Fig. 21).

Besides the red, there are *white corpuscles* in the blood. They differ from the former in their number being much smaller than that of the red; for every five hundred red ones there exists, perhaps, one white corpuscle. During disease this ratio may increase to ten, and even more, for every five hundred. They are larger than the red corpuscles, and possess the peculiarity of alternately contracting and dilating, and otherwise changing their forms.*

* The size and shape of the blood corpuscles vary in different

In Fig. 22, *B*, there are four white; in *A C*, four red corpuscles, as seen through a microscope of very high magnifying power.

FIG. 21.

FIG. 22.

The Use of these little bodies is not well determined. The main purpose of the red seems to be to convey oxygen from the lungs to all parts of the body. It is observable also that they always contain iron. The white seem to be the agents of repair. This is thought to be true because when there is a wound or great inflammation in the body the number of this kind of corpuscles is known to increase.

The Gases Contained in the blood are carbonic acid, oxygen, and a small quantity of nitrogen.

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animals, so that it is possible to discriminate between those of man and of the lower animals.

One hundred volumes of blood contain about fifty volumes of these gases, collectively.

The Specific Gravity of blood at a temperature of 60° F. is about the same as that of water. The temperature of the blood in the human body is generally 100° F. In the animal it has an odor faintly resembling that of the animal from which it came.

The Quantity of blood in the living body is difficult to ascertain; it has been estimated at about one-tenth of the weight of the entire body. In a thousand parts of weight of blood seven hundred and eighty-four parts are water, one hundred and thirty parts are red corpuscles, and the remainder is composed of albumen, fibrine, fat, and other matters. The proper composition of the blood is one of the three most important items in the health of man. The ravages of cholera and of similar diseases seem to result from a decomposition of this life-giving liquid. It will be seen, further on, that the health of the blood depends largely upon our food and upon the air we breathe.

The Uses of the Blood.—Every living organism of the higher sort, whether animal or vegetable, requires for the maintenance of life and activity, a

circulatory fluid, by which nutriment is distributed to all its parts. In plants, this fluid is the sap; in insects, it is a watery and colorless blood; in reptiles and fishes, it is red but cold blood; while in the nobler animals and man, it is red and warm blood.

The blood is the most important, as it is the most abundant, fluid of the body; and upon its presence, under certain definite conditions, life depends. On this account it is frequently, and very properly, termed "the vital fluid." The importance of the blood, as essential to life, was recognized in the earliest writings. In the narration of the death of the murdered Abel, it is written, "the voice of his *blood* crieth from the ground." In the Mosaic law, proclaimed over thirty centuries ago, the Israelites were forbidden to eat food that contained blood, for the reason that "the life of the flesh is in the blood." With the exception of a few tissues, such as the hair, the nails, and the *cornea* of the eye, blood everywhere pervades the body, as may be proved by puncturing any part with a needle.

Of the *uses of the blood* when in the healthy state, the following four may here find a place: —

(1) It is a source of nutritive material, whence the different parts of the body constantly draw for their maintenance.

(2) It keeps all parts of the body warm and moist.

(3) It conveys oxygen to those of the tissues which need this element.

(4) It collects refuse from all parts of the body, and conveys the substances to places whence they may be discharged.*

2. THE ORGANS OF CIRCULATION.

Experiment.— Cut open a fresh plant and observe its juice. Next open an insect for the same purpose; it contains a watery, almost colorless juice or blood.

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* "You feel quite sure that blood is red, do you not? Well, it is no more red than the water of a stream would be if you were to fill it with little red fishes. Suppose the fishes to be very, very small — as small as a grain of sand — and closely crowded together through the whole depth of the stream, the water would look red, would it not? And this is the way in which the blood looks red: only observe one thing — a grain of sand is a mountain in comparison with the little red bodies that float in the blood, which we have likened to little fishes. If I were to tell you they measured about the 3200th part of an inch in diameter, you would not be much the wiser; but if I tell you that in a single drop of blood, such as might hang on the point of a needle, there are a million of these bodies, you will perceive that they are both very minute and very numerous. Not that any one has ever counted them, as you may suppose, but this is as close an estimate as can be made in view of what is known of their minute size."— *Macé's History of a Mouthful of Bread.*

Then cut open a fish; its blood is cold. Lastly, procure some red, warm blood of a recently killed bird, or quadruped.

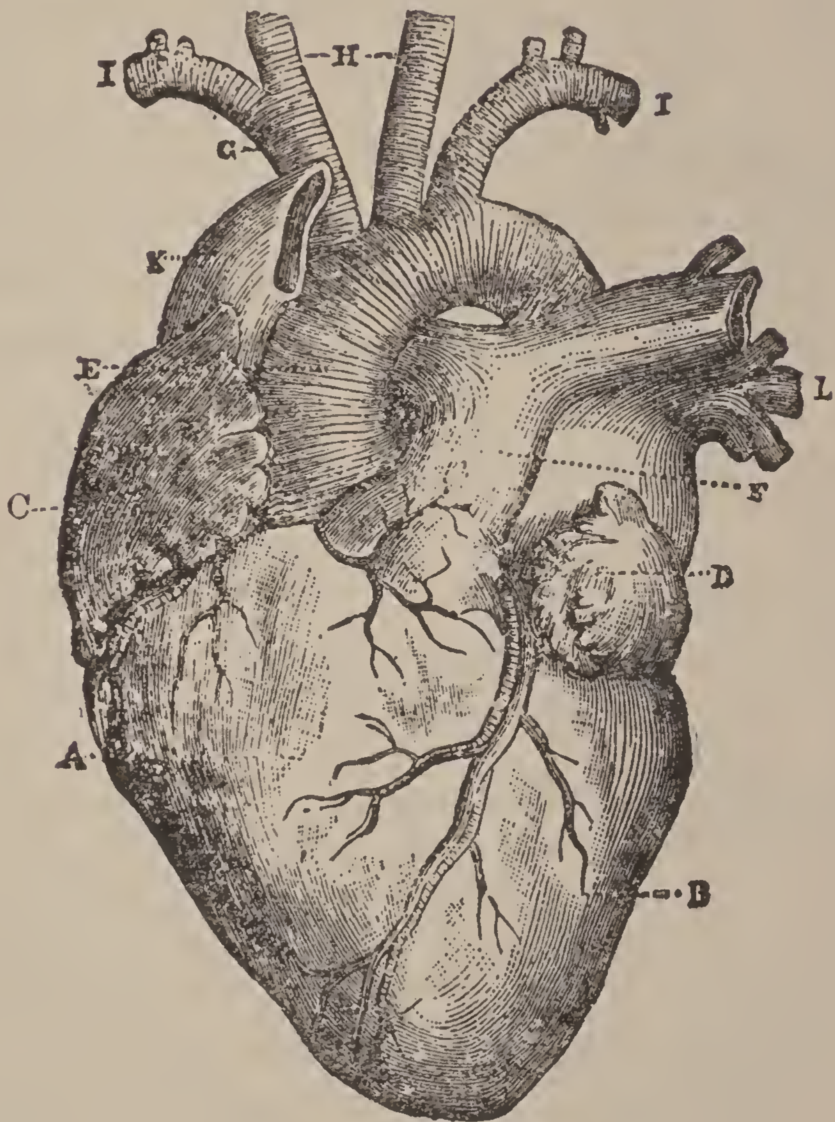


FIG. 23.

HEART, WITH TRUNKS OF PRINCIPAL ARTERIES AND VEINS.

A, right ventricle. *B*, left ventricle. *C*, right auricle. *D*, left auricle. *E*, aorta. *F*, pulmonary artery. *G*, branchio-cephalic trunk. *H*, carotid, right and left. *I*, *I*, subclavian arteries. *K*, superior vena cava. *L*, pulmonary veins.

The preceding shows that organisms have a fluid circulating through the body.

Man and the higher order of animals alone possess warm blood. The "vital fluid" has a definite order in which it travels through the animal system. The circulation in the human body is the same as in mammals and birds.

An uninterrupted current of blood through the body must be maintained. This is evident from the uses of the blood enumerated in the preceding pages. The question now arises, How does nature obtain such an unceasing stream rushing through countless tubes and channels?

The Circulatory Organs through which this is obtained are the *Heart*, *Arteries*, *Capillaries*, and *Veins*.

The Heart (Fig. 23), (represented also by 1, 2, 3, 4, in Fig. 24) is a hollow muscle of about the size of its owner's fist. This muscle has involuntary action, consisting of alternate contraction and dilatation, which goes on without interruption until death.* Owing to the con-

* The heart: "You all know where it is. It is the most wonderful little pump in the world. There is no steam-engine half so clever at its work, or so strong. There it is, in every one of us, beat, beating — all day and all night, year after year, never stopping, like a watch ticking; only it never needs to be wound up,— God winds it up once for all."—*Author of "Rob and His Friends."*

traction, the blood is expelled from the heart through *arteries*, and owing to the dilatation, it returns to the heart through veins.

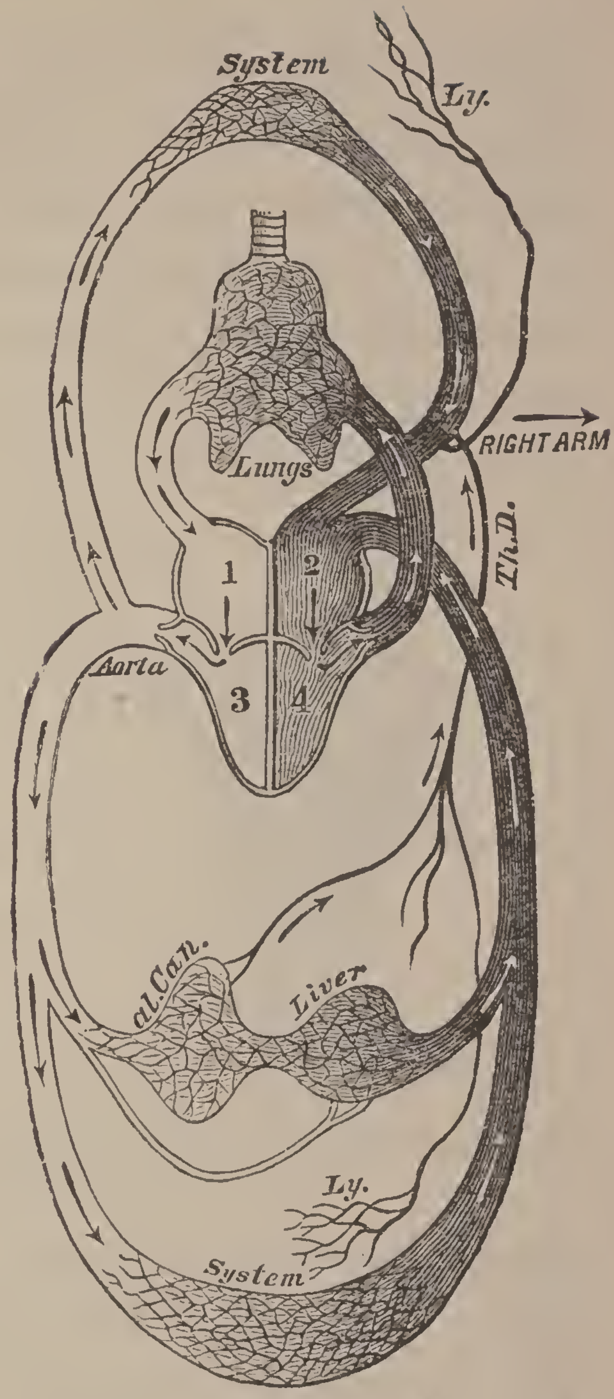


FIG. 24.

A DIAGRAM OF THE CIRCULATION.

Venous Blood.

Arterial Blood.

Capillaries.

Viewed from behind, so that the position of the observer corresponds with that of the figure.

The Heart is Divided by a partition into two sides, right and left (Figs. 24, 25). These two sides do not communicate with each other. Each of them has been subdivided into two portions, an upper and a lower, or into the *auricle* (1 or 2) and *ventricle* (3 or 4) respectively. The heart, therefore, contains two auricles (1, 2) and two ventricles (3, 4). While the two divisions, right and left, are entirely separate from each other, each

auricle communicates with the ventricle of the same side. The opening, however, through which the communication takes place, is so constructed that it acts like a valve, it allows the blood to pass from the auricle to the ventricle, but not in the opposite direction.

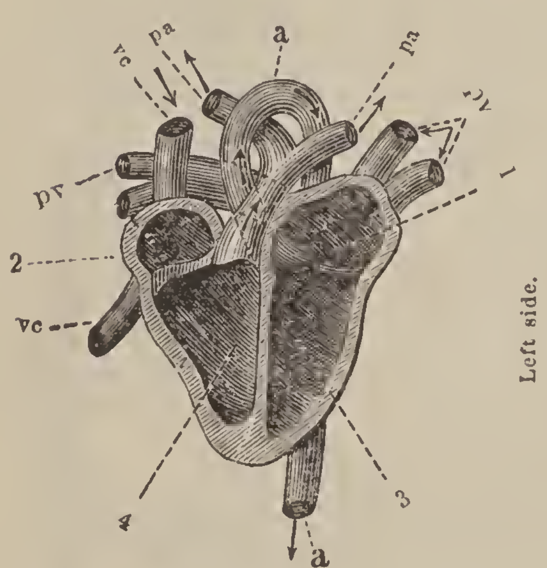


FIG. 25.
The Heart and Large Blood Vessels.

The Course of the Blood from auricle to ventricle is in the same direction on each side. The blood in the right auricle, Fig. 25 (2), is urged into the right ventricle (4), whence it passes through a large artery (*pa*) into the capillaries of the lungs, where it absorbs oxygen, and gives out carbonic acid. This artery is the *pulmonary artery*, one of the few arteries carrying *venous* blood, and called an artery simply on account of it being constructed like the arteries. The blood is then gathered up again and conveyed in large veins (*pv*) to the left auricle. This vein is called the *pulmonary vein* and is the only vein carrying arterial blood. The large vein by which the blood is poured back into the heart

is the *vena cava*. From the left auricle it emerges into the left ventricle (3), the strongest of the four divisions, and thence into the *aorta*, *a*, the strongest of the arteries. The aorta distributes it all over the system, to the capillaries of every portion of the body. In these capillaries the blood becomes impure, and after leaving them it passes through the large veins (*vc*) back into the right auricle (2), whence we supposed it to start.

As stated before, the chief propelling force of the incessant torrent of blood through the body lies in the muscular substance of the heart. But there are several helpers which must not be disregarded: (1), the elastic walls of the arteries (they are not unyielding like gas pipes); (2), the pressure of muscles upon some of the veins; and (3), the contraction and expansion of the chest in breathing. These aids will be better understood hereafter.

The Function of each Subdivision of the Heart may be stated thus:—

a. The right auricle receives the venous blood of the whole body and conveys it to the right ventricle.

b. The right ventricle impels the venous blood through an artery into the lungs.

c. The left auricle receives arterial blood flowing to it through veins from the lungs.

d. The left ventricle forces the blood into the aorta, which distributes it over all parts of the body.

In Comparing the functions of these subdivisions with one another it is found that —

I. The auricles *receive* blood;

The left auricle receives arterial blood from the lungs;
The right auricle, venous blood from the entire body.

II. The ventricles *convey away* blood;

The left ventricle conveys away arterial blood to the entire body;
The right ventricle, venous blood to the lungs.

The Arteries are the cylindrical tubes that convey the blood from the heart to every part of the system. They are dense in structure, and preserve, for the most part, the cylindrical form, when emptied of their blood, which is their condition after death.

The arteries are composed of three coats. The external, or cellular coat, is firm and strong; the middle, or fibrous coat, is composed of yellowish fibres. This coat is elastic, fragile, and thicker

than the external coat. Its elasticity enables the vessel to accommodate itself to the quantity of blood it may contain. The internal coat is a thin, serous membrane, which lines the interior of the artery, and gives it the smooth polish which that surface presents. It is continuous with the lining membrane of the heart.

Communications between arteries are free and numerous. They increase in frequency with diminution in the size of the branches, so that through the medium of the minute ramifications, the entire body may be considered as one circle of inosculation. The arteries, in their distribution through the body, are inclosed in a loose, cellular investment, called a sheath, which separates them from the surrounding tissues.

The Pulmonary Artery (Fig. 25, *pa*) commences in front of the origin of the aorta. It ascends obliquely to the under surface of the arch of the aorta, where it divides into two branches, one of which passes to the right, the other to the left lung. These divide and subdivide in the structure of the lungs, and terminate in the capillary vessels, which form a network round the air-cells, and become continuous with the minute branches of the pulmonary veins. This artery conveys the impure blood to the

lungs, and, with its corresponding veins, establishes the *lesser*, or *pulmonic circulation*.

The Aorta proceeds from the left ventricle of the heart, and contains the pure, or nutrient blood. This trunk gives off branches, which divide and subdivide to their ultimate ramifications, constituting the great arterial tree which pervades, by its minute subdivisions, every part of the animal frame. This great artery and its divisions, with their returning veins, constitute the *greater*, or *systemic circulation*.

The Veins carry blood to the auricles of the heart, after it has been circulated by the arteries and capillaries through the tissues of the body. They are thinner and more delicate in structure than the arteries, so that when emptied of their blood, they become flattened and collapsed. The veins commence by minute radicles in the capillaries, which are everywhere distributed through the textures of the body, and coalesce to constitute larger and larger branches, till they terminate in the large trunks which convey the dark-colored blood directly to the heart. In diameter they are much larger than the arteries, and, like those vessels, their combined area would constitute an imaginary cone, the apex of which is placed at the heart, and the base at the surface of the body.

The communications between the veins are more frequent than between the arteries, and take place between the larger as well as among the smaller vessels. The office of these inosculations is very apparent, as tending to obviate the obstructions to which the veins are peculiarly liable, from the thinness of their coats, and from inability to overcome great impediments by the force of their current. These tubes, as well as the arteries, are supplied with nutrient vessels, and it is to be presumed that nervous filaments from the sympathetic nerves are distributed to their coats.

The external, or cellular coat of the veins, is dense and firm, resembling the cellular tunic of the arteries. The middle coat is fibrous, like that of the arteries, but extremely thin. The internal coat is serous, and also similar to that of the arteries. It is continuous with the lining membrane of the heart at one extremity, and with the lining membrane of the capillaries at the other.

At certain intervals the internal coat forms folds, which are called valves (Fig. 26). They are for the most part composed of two folds, semi-lunar in shape, one on each side of the inner wall of the vein. The free edge of the fold is concave and extends forward in the direction the blood should go, so while the current of blood sets forward towards the heart

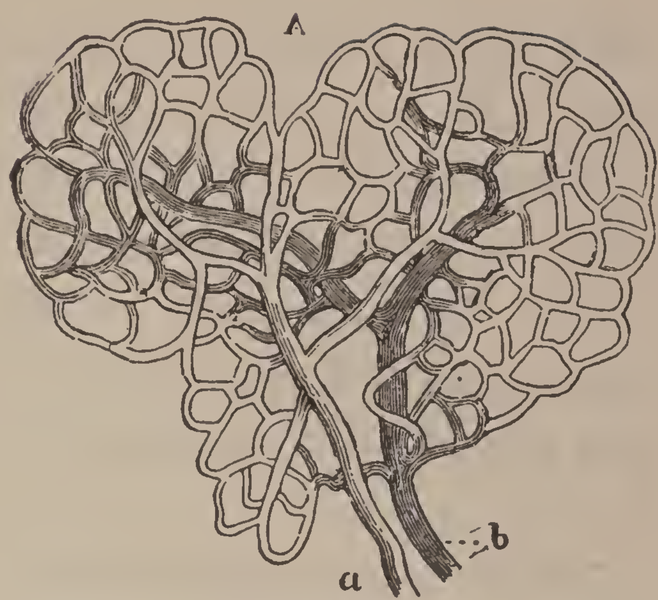
there is no hindrance to the free passage; but if the current is retrograde, it is impeded by their distension. These valves are most numerous in the extremities; but in some of the trunk veins, and even in some small veins, there are no valves.

FIG. 26.
This shows the valves of the veins in action.

The Capillaries (Fig. 27) constitute a microscopic network, and are so distributed through every part of the body as to render it impossible to introduce the smallest needle beneath the skin, without wounding several of these fine vessels. They are remarkable for the uniformity of diameter, and for the constant divisions and communications which take place between them.

The capillaries inosculate, on the one hand, with the terminal extremity of the arteries, and on the other, with the commencement of the veins. They establish the communication between the termination

of the arteries and the beginning of the veins. The important operations of secretion and the conversion of the nutrient materials of the blood into bone, muscle, etc., are performed in these vessels.



CAPILLARIES.

FIG. 27.

3. THE CIRCULATION OF THE BLOOD.

Experiment.— Examine the movements of the heart by placing the fingers between the fifth and sixth ribs, slightly to the left of the breast-bone (as the lower part of the heart inclines a little toward the left). Each contraction of the heart will then be distinctly felt, because the point of the heart strikes against the wall of the chest.

The heart of a living animal, if quickly removed, will continue pulsating for some time. Each pulsation commences at the two auricles, and thence passes to the two ventricles. That is to say, each pulsation of the heart consists of — (1), a simultaneous contraction of both auricles; (2), immediately

after this a simultaneous contraction of both ventricles; (3), a moment of rest or relaxation.

After this rest the contractions commence again in the same order as before, and the relaxations occur also in the same order as before. The work of the heart is carried on, as all labor should be, regularly and continuously, with due regard to rest.

The Two Contractions of the heart with its subsequent repose, are often represented by two short marks and a rest thus: ‿ ‿ —. The contraction of either auricle or ventricle is called its *systole;* the pause during the dilatation of either auricle or ventricle is called the *diastole.* This diastole, or pause, occupies about the same length of time as the two systoles together; so the heart's action has a certain rhythm.

The Action of the Heart may now be explained. It is filled with blood, and the first contraction, or the systole of the auricles, happens. The auricles are, as it were, pressed together, and the liquid within is forced out. Where can it go? On examining Fig. 24, two outlets are found to exist. It may pass back into the veins, or else descend into the ventricles. The amount of resistance encountered in each direction will decide the question. The re-

sistance encountered toward the veins is very great, because exerted by the blood in all the veins; that encountered toward the ventricles will be exceedingly small, because, in the first place, the valves leading into the ventricles are open; in the second place, the walls of the ventricles, in their relaxed state, are easily expanded; and in the third place, the resisting pressure of the arterial blood is rendered naught by the valves between the ventricles and arteries being closed. For these reasons only very little blood will pass back to the veins; nearly all of it rushes at once into the ventricles. When the ventricles are thus filling they become expanded, and the blood getting behind the valves which separate each auricle from its ventricle, the ventricles are soon closed. The contraction of the auricles now ceases, their walls relax and immediately blood from the veins enters them, slowly expanding them again. The auricular systole is now over.

The next movement of the heart is the contraction of both ventricles. The walls of the ventricles are strong and thick; the pressure, therefore, which they produce in suddenly contracting is very great, and has the effect of shutting up the auriculo-ventricular valves so that not a drop of blood can enter the auricles. But it is towards the arteries that the

ventricles meet with most of the resistance. There is the resisting pressure of the blood in the arteries, a pressure which is very great because it is made up—*first*, of the weight of the blood; *second*, of the resistance of the walls of the arteries to further expansion; *third*, of the friction of the blood in the capillaries. All this explains why the walls of the ventricles are built so very strong: they have more work to perform than the auricles. It also shows the necessity of the valves between the auricles and ventricles, and that no valves are needed between the auricles and veins. The auriculo-ventricular valves act like the lower valve in a pump. The whole office of the auricles seems to be to fill the ventricles. And the contraction of the left ventricle forces the blood into the arterial system of the body, while the contraction of the right ventricle impels the blood into the artery of the lungs. This simultaneous contraction of the ventricles forms the ventricular systole.

The Arteries Receive a fresh supply of blood at every systole of the ventricles; during a part of the time in which they transmit the shock, the diastole of the heart occurs. Each ventricle contains about three ounces of blood; the whole of this passes, at each contraction, into the respective arteries. The

great pressure of this quantity of blood (about one-fifth of the pressure of the atmosphere) suddenly forced into the main arteries, necessarily distends them, because they are elastic and yielding; but a reaction takes place, and the elastic walls of the arteries contract again. This contraction has two effects in opposite directions: it causes, *first*, the valves between the arteries and ventricles to close instantly; *second*, the blood to pass from the larger to the smaller arteries. Thence the fluid enters the ramification of the capillaries (Fig. 27). A little reflection will show that a corresponding quantity of blood passes at the same time from the capillaries through the veins back toward the heart. *The effect*, then, of the ventricular systole is — (1), the propulsion of blood through the arteries into the capillaries; and (2), the return of the fluid from the capillaries through the veins to the heart.

The impulse given at every ventricular systole to the blood in the aorta is spent in urging the blood forward through the arteries; and, next, in distending the elastic walls of the arteries. This sudden expansion produces a sudden recoil, and gives rise to a phenomenon, which is called the *pulse*. The pulse proper is the expansion of the artery, felt on examining the artery. Each pulsation naturally means a systole of the ventricles. Such pulsations

may be felt wherever arteries are exposed to the touch, as on each upper side of the neck, in front of the ear, or above the wrist. At the wrist the pulse is felt to be a little later than at the heart or middle of the neck. It occurs later, according to the distance from the heart at which the artery is examined. To feel the pulse, the wrist is selected by physicians for convenience sake. The pulse is the index of the motions of the heart. Its regularity, strength, fullness, and a number of peculiarities, indicate the state of affairs respecting the heart and its fluid.

The Sounds of the Heart may be distinctly heard by placing the ear closely over the heart. They should occur with great regularity — first, a prolonged, dull sound, somewhat like that of the word *lubb;* then a short and sharp sound; nearly like that of *dup;* then comes a pause; then the long sound again, and then the short sound; then the pause, the long sound, and so on. The sharp, short sound comes from the sudden closing of the valves between the ventricles and the arteries; the cause of the long sound is not fully known, as yet.

The capillaries are pulseless, because on reaching them the shock is spread over a large network of capillary tubes; this makes its effect imperceptible. For the same reason, the blood in the capillaries

flows steadily, while from a severed artery it jets forth in jerks. The elasticity of the arteries seems to do for the blood what an air chamber does for the water of a pump.

From what has been said in regard to the arteries, their uses chiefly are — *first*, to convey blood to the system, and *secondly*, to convert the jerking motion of the blood into a uniform flow.

Experiment.— Clasp the lower part of the arm tightly a little above the wrist; the veins on the back of the hand will soon distend, and knotty points become visible. When the pressure is removed they will empty themselves, and the swelling disappears. Now, why did this not completely check the circulation of the blood? There are two reasons: In the first place, the veins communicate with each other by means of many branches, so that whenever the blood, for any reason, be stopped in one vein, it at once passes through branch vessels to another, unimpeded vein, and finally to the heart. But it may be argued that in the above experiment the arm had been encircled with so much pressure that even the branch vessels were closed. Circulation, would, nevertheless, have continued, because, in the second place, the veins are provided with valves (Fig. 26) which are open as long as the fluid flows

toward the heart, but which close when it moves in the opposite direction. Those knotty places were the closed valves, preventing the backward flow of the blood to the capillaries.* Were it not for this valvular action in the veins, any such disturbance as the one occasioned by the experiment, would impel the blood to the capillaries, where it would resist, and finally overcome, the onward motion of

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* *Course of the Blood in the Capillaries.*—"The phenomena of the capillary circulation are only observable with the aid of the microscope. It was not granted to the discoverer of the circulation to see the blood moving through the capillaries, and he never knew the exact mode of communication between the arteries and veins. After it was pretty generally acknowledged that the blood did pass from the arteries to the veins, it was disputed whether it passed in an intermediate system of vessels, or became diffused in the substance of the tissues, like a river flowing between numberless little islands, to be collected by the venous radicles and conveyed to the heart. Accurate microscopic investigations have now demonstrated the existence, and given us a clear idea of the anatomy of the intermediate vessels. In 1661 the celebrated anatomist Malpighi first saw the movement of the blood in the capillaries, in the lungs of a frog. This spectacle has ever since been the delight of the physiologist. We see the great arterial rivers, in which the blood flows with wonderful rapidity, branching and subdividing, until the blood is brought to the superb network of fine capillaries, where the corpuscles dart along one by one, the fluid then being collected by the veins and carried in great currents to the heart."—*Flint.*

the blood in the arteries, which would speedily interrupt the circulation.

The Frequency of pulsations depends upon the age, sex, and health of a person. During the first years of life about 130 pulse-beats may be counted in a minute, while twenty years later the same person's pulse will beat nearly 70 times, and increase again toward old age. The pulse of women beats more rapidly than that of men.

4. THE LYMPHATIC CIRCULATION.

Closely associated with that of the blood is the *Lymphatic Circulation.* This is far more delicate in its organization, however, and is not so fully understood. It reaches almost every part of the body in a second series of capillaries interlaced with the blood-capillaries whose function seems to be the removal of matter which has been deposited.

In Structure these vessels resemble the lacteals mentioned under the subject of digestion.

They exist in great numbers in the skin and mucous membranes, particularly those of the lungs. Though no lymphatics have been traced to the brain, it is presumed that they exist

there, as this part of the body is not exempt from the composition and decomposition, which are perpetual in the body. These vessels are extremely minute at their origin, so that in many parts of the system they cannot be detected without the aid of a microscope.

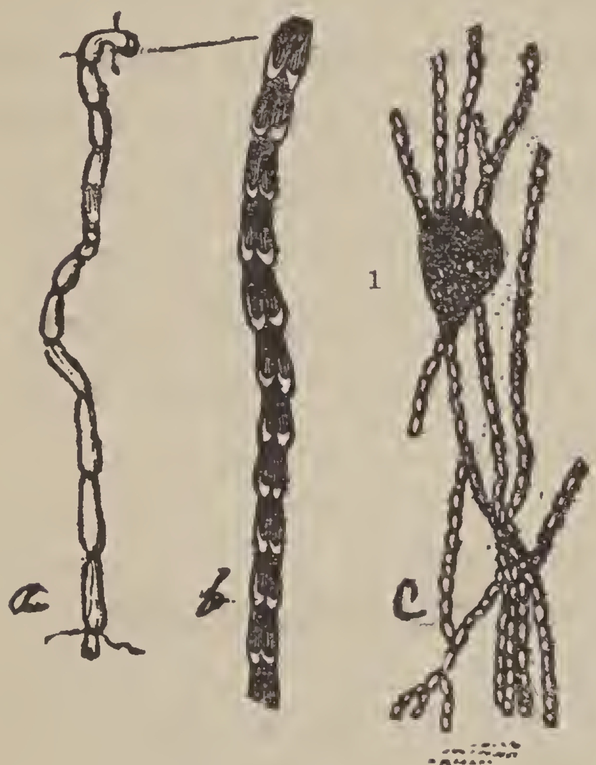

FIG. 28.

a. A single lymphatic vessel, much magnified.

b. The valves of a lymphatic trunk.

c. 1. A lymphatic gland with several vessels passing through it.

The lymphatic vessels, like the veins, diminish in number as they increase in size, while pursuing their course toward the large veins near the heart, into which they pour their contents. The walls of these vessels have two coats of which the external one is cellular, and is capable of considerable distention. The internal coat is folded so as to form valves like those in the veins. Their walls are so thin, that these folds gives them the appearance of being knotted.

At certain points, the lymphatic vessels pass through distinct, soft bodies, peculiar to themselves,

which are called *lymphatic glands*, which are to these vessels what the mesenteric glands are to the lacteals. The lymphatic glands vary in form and in size. They are extremely vascular, and appear to consist of

FIG. 29.

Lymphatics of the Head and Neck, showing the Glands, and *B*, the thoracic duct as it empties into the left innominate vein at the junction of the left jugular and subclavian veins.

a collection of minute vessels. These glands are found in different parts of the body, but are most numerous in the groins, axilla, or arm-pits, neck, and cavities of the chest and abdomen.*

* From exposure to cold, these glands are frequently enlarged and inflamed. They are then known under the name of "kernels." They are often diseased, particularly in scrofula, or "king's evil."

The Lymph, which circulates through the lymphatic system, is a thin, colorless liquid similar to the serum of the blood. It is gathered up by the lymphatics and after undergoing some change in the glands not well known, is poured into the blood through the thoracic duct into the *vena cava* in the neck. The lymphatics perform the office of absorption chiefly in the skin.* When a wound, a cut or the like, is to be healed an excess of matter is deposited in the sore. Soon these vessels remove the surplus material to other parts of the body.

5. HYGIENE AND DISORDERS OF THE CIRCULATORY SYSTEM.

The Vitality and Vigor of every part of the human body depend upon the condition of the blood and its circulation. The conditions which will favor this requirement may be stated in the following rules:—

(1) *The Clothing should be Loosely Worn.*—Compression of any kind, impedes the passage of blood through the vessels of the compressed portion.

* Pain is often relieved by injecting under the skin a solution of morphine. The lymphatics take up the drug and carry it through the system.

Hence, no article of apparel should be worn so as to prevent a free flow of blood through every organ of the body.

The blood which passes to and from the brain flows through the vessels of the neck. If the dressing of this part of the body is close, the circulation will be impeded, and the functions of the brain will be impaired. This remark is particularly important to scholars, public speakers, and individuals predisposed to apoplexy, and other diseases of the brain.

As many of the large veins through which the blood is returned from the lower extremities, lie immediately beneath the skin, if the ligatures used to retain the hose, or any other article of apparel, in proper position, be tight and inelastic, the passage of blood through these vessels will be obstructed, producing, by their distention, the varicose or enlarged veins. Hence elastic bands should always be used for these purposes.

(2) *An Equal Temperature of All Parts of the System Promotes Health.*— A chill on one portion of the body diminishes the size of its circulating vessels, and the blood which should distend and stimulate the chilled part, will accumulate in other organs. The deficiency of blood in the chilled portion induces weakness, while the superabundance

of sanguineous fluid may cause disease in another part of the system.

(3) *The Skin should be kept not only of an Equal but at its Natural Temperature.*— If the skin is not kept warm by adequate clothing, so that chills produce a contraction of the blood-vessels and a consequent paleness, the blood will recede from the surface of the body, and accumulate in the internal organs. Cleanliness of the skin is likewise necessary, for the reason that this condition favors the free action of the cutaneous vessels.

When intending to ride on a cold day, wash the face, hands, and feet, in cold water, and rub them smartly with a coarse towel. This is far better to keep the extremities warm than to take spirits into the stomach.

(4) *Exercise Promotes the Circulation of the Blood.*— As the action of the muscles is one of the important agents which propel the blood through the arteries and veins, daily and regular exercise of the muscular system is required to sustain a vigorous circulation in the extremities and skin, and also to maintain a healthy condition of the system.

(5) *The State of the Mind has Great Influence Upon the Circulation.*— Let there be *hope* and *joy*

and the system is more fully nourished and capable of greater extension, than when despair and sorrow prevail.

(6) *The Blood Should be Pure and Abundant.*— In consequence the organs will act more energetically.

(7) *Absorption into the Lymphatics is Greatest When There is Some Break in the Cuticle.*— Through the lymphatic capillaries poison may be communicated to the blood from the surface of the body. Great care should be exercised as to the cleanliness of a cut or other wound to avoid such a thing. Very serious cases of blood-poisoning have occurred by neglecting this precaution.

Diseases of this system are so common that a few remarks concerning them may not be out of place in this connection.

(1) *Congestion*, as the term indicates, is an undue accumulation of blood in any particular part of the body. This is known by redness of the part beyond the normal appearance. This may become a permanent condition as in the case of the man addicted to drink when his nose becomes red. The vital organs

may become gorged with blood, producing very serious results. *Blushing* is a temporary congestion, due to nervous excitement which causes an expansion of the capillaries for an instant, thus allowing an unusual amount of blood in that part, usually the face.

(2) *Inflammation*, simply a burning, is a more or less permanent congestion of some part of the body. There are four characteristics of this disorder — *redness*, *heat*, *pain*, *swelling*. Catarrhal affections are inflammations of the mucous linings of the various passages in the body. The most common of these troubles are those of the nasal and bronchial tubes. On going out from the hot, dry air of a warm room, into a cold, damp atmosphere, it is almost impossible to avoid irritation and inflammation of this tender membrane. If our rooms were heated less intensely and ventilated more thoroughly this disease of catarrh would be far less common.

(3) *Scrofula* is a blood trouble which is inherited. It affects the glands of the lymphatic system. Yet it may attack any organ. To ward off approaches of this disease it is necessary to use the utmost care in diet and exercise; to look well to pure air and warm clothing, avoiding late hours and undue use of stimu-

lants. Impure air and insufficient food are the greatest causes of scrofulous attacks.

(4) *A cold* is caused by the skin being chilled and the perspiration stopped. The effect is that the blood is not purified as it should be by the proper action of the pores of the skin. The lungs are consequently burdened with extra work and the membranes of the lungs and bronchial tubes are irritated. This irritation amounts in short to congestion and then inflammation. In general it may be taken as a truth that the excess of blood will seek the weak part and there develop latent disease. When this congestion locates in the membranes of the nasal cavities we have "a cold in the head," or a *catarrh*. By a hot foot-bath the equipoise is partially restored by gorging the feet with blood, thus relieving the congested part. No other one thing is so efficacious in the treatment of a cold as a hot foot-bath. It has saved many lives.

Yet it should not be thought that a "cold" is the great cause of diseases. In this connection we quote from an eminent authority:—

"A reform is greatly needed in respect to 'catching cold.' Few diseases are referable to the agency of cold, and even the affectation commonly called a cold is generally caused by other agencies, or, perhaps, by

a special agent, which may prove to be a microbe. Let the axiom, '*A fever patient never catches cold*,' be reiterated until it becomes a household phrase. Let the restorative influence of cool, fresh, pure atmosphere be inculcated. Let it be understood that in therapeutics, as in hygiene, the single word *comfort* embodies the principles which should regulate coverings and clothing."—*Austin Flint, M. D., in the New York Medical Journal.*

(5). *The Heart is Injured by Overexertion.*—"During exertion, if the heart is not oppressed, its movements, though rapid and forcible, are regular and equal. But when it becomes embarrassed, the pulse-beats are quick, unequal, and at last become irregular, indicating injury to the organ. All great and sudden efforts are to be carefully avoided; excessive exercise often produces palpitation, and sometimes enlargement and valvular diseases of the heart."—*Huxley*.

"No great intellectual thing was ever done by great effort; a great thing can only be done by a great man, and he does it without effort. The body's work and the head's work are to be done quietly, and comparatively without effort. Neither limbs nor brain are ever to be strained to their utmost; that is not the way in

which the greatest quantity of work is to be got out of them; they are never to be worked furiously, but with tranquillity and constancy. We are to follow the plow from sunrise to sunset, but not to pull in race-boats at the twilight; we shall get no fruit of that kind of work — only disease of the heart."— *Ruskin.*

Important Facts. — The hearts of all Mammals have two auricles and two ventricles. In quadrupeds the heart lies on the middle line of the body, and not to the left of it as in man. The blood of birds has the highest temperature of the vertebrate animals. In all reptiles the heart has two auricles and *one* ventricle; and their blood is cold. The heart of the fish has one auricle and one ventricle. In the crab and the lobster the heart consists of a single ventricle. Insects have neither arteries nor veins. Coagulation of the blood, which is of so much value as a means of stopping hemorrhages, is greater in the lower animals, in some species of birds almost instantaneous. This seems to be a wise provision since these animals cannot stop a flow of blood from a wound by artificial means. The office of fibrine is thought to be to stanch hemorrhage. The blood of man carries a great amount of iron. Enough has been found in the ashes of a burned body to make a ring the size

of an ordinary finger-ring. The fact that the arteries and veins in all parts of the body are connected by cross branches, makes it possible to amputate a limb and yet leave the circulatory system intact. A deep breath helps the flow of blood in the veins and a cut, or wound, may suck in air with fatal effect. A maimed horse is most mercifully killed by blowing a bubble of air into the veins of his neck. A whale has no valve in his veins because the pressure of the sea would burst them; hence a small wound by a harpoon causes him to bleed to death. The circulation of the blood was discovered by Harvey in 1619. He kept it a secret for a long time. When he at length published it he was bitterly persecuted. He lived, however, to see his theory universally accepted. Our bodies change entirely every few years — some say the period is seven years; this must vary according to the manner of life. The amount of work performed by some organs of the body is truly wonderful. The heart beats forty million times per year. Dr. Holmes has said that our brains are seventy-five-year clocks. It may be interesting here to take a comparative view of the heart-beats in different animals shown by a table compiled from experiments made in Paris. The pulse of a lion beats forty times a minute; that of a tiger, ninety-six times; of a tapir, forty-four times; of

of a horse, forty times; of a wolf, forty-five times; of a fox, forty-three times; of a bear, thirty-eight times; of a monkey, forty-eight times; of an eagle, one hundred and sixty times. It was impossible to determine the beatings of the elephant's pulse. A butterfly, however, it was discovered, experienced sixty heart pulsations in a minute.

REVIEW QUESTIONS.

1. Give an experiment by which the composition of the blood may be shown.
2. What is the composition of the blood?
3. Describe the corpuscles of the human blood?
4. What is said of their use?
5. What gases are contained in the blood?
6. What can you say of the quantity of blood in the body?
7. Why is the blood called "the vital fluid?"
8. What ancient reference to *blood* can you give?
9. State the *four* chief uses of the blood?
10. Why should there be organs for circulation?
11. Name these organs.
12. Describe the heart.
13. Locate the auricles.
14. Locate the ventricles.
15. What are the vessels leading from the heart?
16. What are the vessels leading to the heart?
17. Why is the left side of the heart the stronger?
18. Why is the aorta the strongest of the arteries?
19. State the function of each subdivision of the heart.
20. Compare the auricles and the ventricles as to work.
21. Describe the arteries.
22. What is the work of the pulmonary artery?
23. What organs in the pulmonic circulation?
24. What organs in the systemic circulation?
25. Describe the veins.
26. What are the valves of the veins?
27. What are the capillaries?

28. Locate them.
29. Describe the actions of the heart.
30. Trace the circulation.
31. How may we show the location of the valves in veins?
32. What can you say of the frequency of the pulse-beats?
33. Describe the lymphatic circulation.
34. What are its uses?
35. Where are they most numerous?
36. Into what organ do they empty their contents?
37. What are the lymphatic glands?
38. Where are they?
39. What is the lymph?
40. How may pain be relieved?
41. Upon what does the vitality and vigor of the body depend?
42. State the law of hygiene for the clothing.
43. Discuss the rule of equal temperature.
44. What does exercise have to do with the circulation?
45. The state of the mind?
46. What care should be exercised as to absorption?
47. Describe congestion.
48. What is blushing?
49. What are the signs of inflammation?
50. What is a cold and what some of its consequences?
51. What is a good treatment for a cold? Why?
52. State five important facts.
53. Who discovered the circulation of the blood?

BLACKBOARD OUTLINE.

THE CIRCULATORY SYSTEM.

1. **The Blood.**
    1. Composition.
    2. Uses.
    3. Coagulation.
    4. Quality.

2. **The Organs of Circulation.**
    1. The Heart.
        - Divisions and Walls.
        - Valves.
        - Movements.
    2. The Arteries.
        - Structure and Character
        - Main Branches.
        - The Pulse.
    3. The Capillaries.
        - Description.
    4. The Veins.
        - Structure.
        - Valves.

3. **The Circulation.**
    1. The Pulmonic Circulation
    2. The Systemic Circulation.
    3. The Lymphatic Circulation.
        - Description.
        - The Glands.
        - The Lymph.

4. **Hygiene and Disorders.**
    1. Laws of Health.
    2. Diseases.
        - Congestion.
        - Inflammation.
        - Scrofula.
        - Cold.
        - Over-exertion.

VI.

THE RESPIRATORY SYSTEM AND VOICE.

Look in upon thy wondrous frame!
The smooth, soft air with pulse-like waves
Flows murmuring through its hidden caves,
Whose streams of brightening purple rush,
Fired with a new and livelier blush,
While all their burden of decay,
The ebbing current steals away.

— *Holmes, "The Living Temple."*

VI. The Respiratory System and Voice.

1. INTRODUCTION.

In the Preceding Chapter the Blood has been traced in its travels through the body, but now the discussion of how the blood reaches the air in the lungs and is there purified, again to begin its journey through the system, will be taken up, and the process fully explained.

The first object in the process of respiration is to supply the system with oxygen, which is absolutely necessary to the life of tissues. Again, the process of respiration relieves the system of waste matter, chiefly carbon, with watery vapor. The gluten of vegetable food is also converted into *fibrine* through the influence of the air upon the blood.

Wherever man sojourns, whether within doors or out, whether below, above, or at the surface of the earth, he requires, night and day, an incessant supply of air, which he mainly uses for food, and as a means of cooling the body.

(Our atmospheric air is a mixture of two gases—nitrogen and oxygen; only the latter is available

for food; nitrogen is not utilized for any purpose by the blood. It merely dilutes the oxygen, which otherwise would be too strong. Oxygen forms one-fifth of any given volume of the atmosphere; nitrogen, the remaining four-fifths including a little watery vapor, carbonic acid gas.)

The human body, in order properly to carry on the functions of life, requires a *constant* internal temperature, which, in summer and winter, must be the same. Experiments have shown this temperature to be between 98° and 100° F.; and, as it does not vary under ordinary circumstances, this *vital* or *animal* heat, as it is called, must be generated in, and distributed through, the interior of the body at every instant of time. In severe cold weather the temperature of the air may be so low that one's ears or finger-ends may be cooled a few degrees below 98°, or even congeal; but the temperature of the interior organs and of the blood remains unchanged. Should the cold be very intense, however, and affect the body continuously, then the temperature of the blood will be reduced, and the consequences be fatal. A decrease of five degrees below the normal standard of temperature will cause the vital processes to cease.

A temperature not varying more than one degree from 99° F., whatever be the temperature of the

surrounding air, is one of the three most important requirements for health.

How the Heat of the Body May Be Maintained.— It is obvious that the maintenance of the standard temperature of the body must be one of our main cares. Heat may be lost—(1), By *conduction;* (2), By *radiation;* and (3), By *evaporation.*

(1) Loss of Heat by Conduction — Experiment.—The end of a wire held in a flame has a higher temperature than its nearest part outside the flame, while the end of the wire which is held in the hand is comparatively cool. We say now that the wire is unequally hot; and because of this inequality of temperature, the heat commences to pass from the hotter to the colder portions of the wire, so that, finally, the hand can no longer hold it.

In the same manner the human body transfers heat to any substance in contact with it and colder than itself, such as air, water, or clothing.

The passage of heat from hotter to colder portions of a body, or from hotter to colder adjacent bodies, is called the conduction of heat.

If, by way of experiment, we were to step from a heated room suddenly into an apartment whose

temperature was 32° F., a great deal of heat would be conducted away from the body, and the loss would at once be seriously felt; but were we, in a heated state, to plunge into ice-cold water, the loss of heat would be far greater — that is, the water would take more heat from the body than the air, and we should be chilled instantaneously. This shows that water is a better conductor of heat than air. It also explains why we take cold more easily in moist and cold weather, than in dry and cold.

(2) **Loss of Heat by Radiation — Familiar Facts.**— On a bright, calm day in winter we feel the sun's rays to be quite warm, although the water on the ground is freezing, and the ice is dry and hard. The thermometer indicates a temperature below the freezing point, but when the direct rays of the sun fall on it, it rises at once, indicating a far higher temperature. This shows that the sun's rays pass through the air without heating it, but that they heat any object, such as a solid body, which stops them.

This passage of heat-rays from one body to another without affecting the air through which they pass is called the radiation of heat. It differs from conduction, inasmuch as the radiating body is not in contact with the body heated, while conduction means the

passage of heat from hotter to colder parts of the same substance, or of adjacent bodies.

On a cold day, if a person is seated by a window in a warm room, his loss of heat by radiation is only partial, and, therefore, more dangerous than an equal radiation from all parts of his body, such as takes place when he is walking out of doors. A partial radiation may produce a cold, and, if continued, entail serious injuries upon the system.

As the human body heats the air around it by conduction, and as warm air has less specific weight than cold air, currents of warmed air continuously ascend along the body. These currents are interfered with by the atmosphere, which constantly penetrates to the body, becomes heated at its expense, and thus exerts a cooling influence upon it. Hence, we feel colder when windy weather sets in, although the thermometer shows no reduction of temperature.

All bodies continually tend to equalize their temperatures by the diffusion of heat. This diffusion of heat takes place by conduction and radiation.

(3) **Loss of Heat by Evaporation — Familiar Facts.** — A few drops of alcohol or ether, placed upon the bulb of a thermometer, will rapidly evaporate; this causes an immediate reduction of temperature, which is indicated by the thermometer.

So, snow and ice, when melting on the ground, reduce the temperature of the air.

Now, evaporation means the conversion of a liquid into the gaseous state. The conversion of solids into the liquid or gaseous state is called melting or fusion.

Whenever substances evaporate or melt, they absorb heat; this heat is taken from the adjacent body, and this body is thereby chilled.

In the case of the alcohol, the heat was given to it by the thermometer; in the case of snow and ice melting on the ground, the heat was communicated by the air. Both, the thermometer and the air, under those circumstances suffered a loss of heat; this is the reason why the thermometer sank, and the air became chilled.

2. THE ORGANS OF RESPIRATION AND VOICE — THEIR STRUCTURE.

The blood nourishes the different parts of the body, and at the same time removes effete matter — that is, all such particles as have served their functions in the body. This gives rise to two distinct kinds of blood, the *arterial*, or nutrient, and the *venous*, the carrier of waste matter. The most important difference between the

two is, that venous blood contains less oxygen and more carbonic acid gas than the arterial. The latter is of a scarlet color, but in passing through the capillaries of the body it is converted into venous blood, at the same time becoming darker. The venous blood passes from the heart to the lungs, where it is converted into arterial blood by the absorption of oxygen gas. This conversion is mainly effected by the peculiar structure of the lungs; it is aided by the acts of inspiration and expiration, as well as by other processes. The conversion takes place during the passage of venous blood through the capillaries of the lungs aided by the other organs of respiration (Fig. 30).

The Organs of Respiration are: *The Lungs, the Air-Passages, the Pleura, the Larynx, the Trachea, the Bronchi, and some Muscles, including the Diaphragm.*

The Lungs occupy the greater portion of the chest cavity; in fact, about four-fifths of it; they are situated on both sides of the heart, and are of a pinkish gray color, and dotted with black spots (Fig. 30). They receive air through the larynx and the trachea, which communicate with the external air by two channels — the mouth and the nasal tubes. The

mouth can be opened or closed at will; the nasal passages are not subject to the will. The left lung

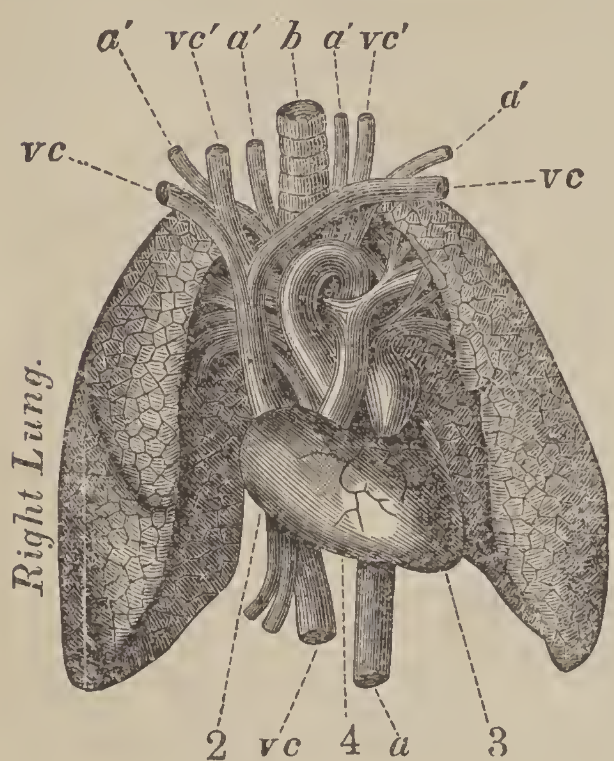

FIG. 30.

LUNGS, TRACHEA AND HEART.

a Aorta. *á* Arteries.
b Trachea. *vc* Veins entering 2.
2 Right Auricle.
3 Left Ventricle, with Left Auricle above.
4 Right Ventricle.
Pulm. Art. and Pulm. Veins.
(*pa* and *pv*, Fig. 25) visible.

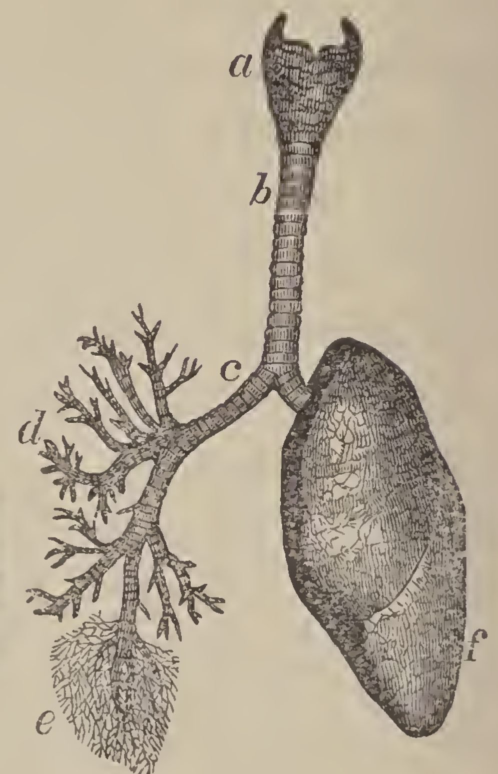

FIG. 31.

TRACHEA, BRONCHIAL TUBES AND LEFT LUNG.

a Larynx.
b Trachea.
c Right Bronchus.
d Small Bronchial Tubes.
e Minute Bronchial Tubes.
($\frac{1}{60}$ in diameter.)

consists of two separate portions called *lobes;* the right lung has three lobes (see Fig. 30). Each lung is composed of a soft spongy, elastic substance, and is often compared to a bag. Each is attached to one of the two bronchi (Fig. 31, *c*).

These Bronchi, or Bronchial Tubes, after entering the lungs, divide and subdivide into a great number of smaller and smaller tubes having a diameter of about $\frac{1}{25}$th of an inch (*d*), which penetrate to every part of the lungs. The trachea and bronchial tubes, owing to their cartilages, are unyielding, so as to remain permanently open; the finer tubes (*e*), about $\frac{1}{60}$th of an inch in diameter, have no cartilages; therefore, they may be closed by contraction. The minute portion of a lobe is called a *lobule;* a lobule is a little lung of itself. Each minute bronchial tube passes into a lobule. After entering the lobule, the small bronchial tube divides still further into smaller branches (Fig. 32), whose walls at length become exceedingly thin. The mucous membrane, lining the air-passages of the lungs, has its outside portion covered with peculiar cells. Examined under a microscope, it is found that these cells have extremely small hair-like processes, called *cilia*, all in motion, waving like a field of grain. This motion is towards the entrance of the lungs, and probably this is a wise

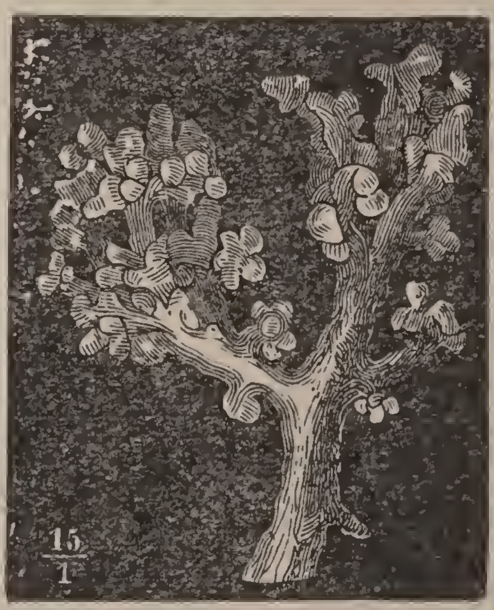

FIG. 32.
Bronchial Tubes, with Air-Cells magnified 15 times.

provision of the Creator to carry foreign substances from the delicate passages. Each such minute branch widens at its end into a caecal *air-cell.*

An air-cell, therefore, is a minute cavity of about $\frac{1}{140}$ of an inch in diameter (Fig. 36). The air-cells are arranged singly, or in groups so that a series of cells open into the same bronchial tube. The lungs are made up of air-cells. Each air-cell carries a network of capillaries — that is, of minute blood vessels of about $\frac{1}{3000}$ of an inch in diameter; this net-work is so dense that its open spaces, or meshes, are even narrower than the capillaries themselves. Between the air in the cells, then, and the blood in the capillaries are but two delicate membranes, that of the cells and that of the capillaries.

The Trachea, or windpipe (Fig. 12), is a tube of cartilaginous nature about an inch in diameter, composed of about twenty cartilaginous rings, beginning opposite the fifth cervical vertebra and extending down to the top of the breast-bone, where it divides into two branches, one leading to each lung, where the tubes ramify and divide into numberless smaller bronchial tubes.

The rings of the trachea are complete only in front; in the rear, where the trachea rests against the gullet,

their ends are connected with each other by a thin membrane and by muscular fibres.

An excellent idea of the form of the trachea with the bronchi and their ramifications may be obtained by comparing their organs with a tree, whose trunk represents the windpipe; the two large branches, the bronchi; the smaller branches, the ramifications of the bronchial tubes, and the buds, the air-cells.

The Larynx (see page 39, Fig. 12) is a cartilaginous tube of conical shape, connecting the *pharynx* and the *trachea*. It is a sort of box, in which the vocal cords are placed, whose vibrations produce sound. In fact, the larynx is the organ of the voice. It contains within its cartilages, immediately below the epiglottis, two elastic lips, known as the vocal cords. These cords are controlled by certain muscles, so that they can close the larynx against the passage of air to or from the lungs. They can also be relaxed, or shortened and lengthened, so as to throw currents of air passing between them into vibrations — that is, so as to produce sound. During inspiration the vocal cords are widely separated; during expiration they relax somewhat, and are nearer together. Just back of the tongue is an opening, the *glottis*, leading to the *larynx;* there is a flesh-

like covering over the glottis, called the epiglottis, the use of which will be explained later.

The Pleura is a serous membrane, immediately investing the lungs. The walls of the chest are lined with a similar membrane. When the lungs are inflated, these two membranes move upon each other without friction or inconvenience. Being lubricated, like other serous membranes, the lungs are thus allowed to move smoothly and freely during respiration.

The bronchi, air-passages, and air-cells have been considered under the topic, *The Lungs*. However, it might be stated that the air-passages are composed of cartilage and fibro-cartilage, lined with mucous membrane.

The Muscles of Respiration are the *Diaphragm* and the *muscles* of the *chest*, *abdomen*, and *back*.

The Organs of Voice and Their Structure.— The Larynx (see page 163, Fig. 34) is the chief organ of voice and is made up of seven distinct cartilages: Two Arytenoid (pitcher-shaped), two Cuneiform (wedge-shaped), one Cricoid (ring-like), one Thyroid (shield-like), and the Epiglottis (cover to the glottis) explained heretofore. These together

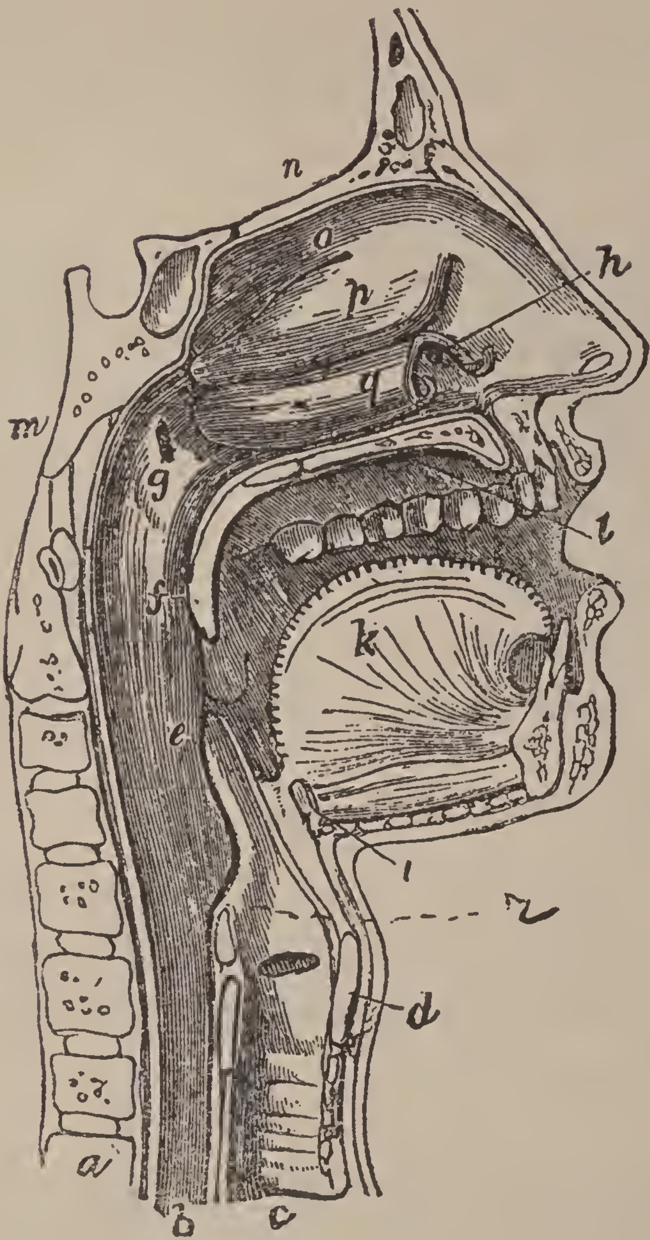

FIG. 33.

A SECTION OF THE MOUTH AND NOSE TAKEN VERTICALLY A LITTLE TO THE LEFT OF THE MIDDLE LINE SHOWING PARTS OF THE LARYNX.

a, the Vertebral Column. *b*, the Gullet. *c*, the Windpipe. *d*, the Thyroid Cartilage of the Larynx. *e*, the Epiglottis. *f*, the Uvula soft palate. *g*, the opening of the left Eustachian Tube. *h*, the opening of the left Lachrymal Duct. *i*, the Hyoid Bone. *k*, the Tongue. *l*, the Hard Palate. *m*, *n*, the base of the Skull. *o*, *p*, *q*, the Superior, Middle, and Inferior Turbinal Bones. The letters *g*, *f*, *e*, are placed in the Pharynx.

with some muscles and the vocal cords form the voice-box, or Adam's Apple, so prominent upon the front part of the neck.

The *Thyroid* is a thin expanded cartilaginous plate, bent in the middle, and forming the chief part of the *Pumum Adami.* It is the frame-work for the movable portions of the organs of voice.

The *Cricoid*, like a seal-ring in form with the broad part to the back, is situated on the top of the *trachea*, and forms the base of the larynx.

The *Arytenoid* cartilages, the two three-sided pyramidal parts, rest upon the upper edge of the back part of the *Cricoid*, and are much more movable than the other parts of the larynx, having a ball and socket joint.

The *Cuneiform* cartilages are about half an inch in length with both extremities enlarged.

The *Epiglottis*, having the shape of a cordate leaf, is fastened by its apex to the upper margin of the *glottis*. It is capable of much motion, and serves to deaden sounds.

The *vocal cords* are stretched across the middle of the larynx just beside the glottis. There are two

pair of folds, the upper and the lower, denominated, the *false cords* and the *true cords*. The false cords are fixed.

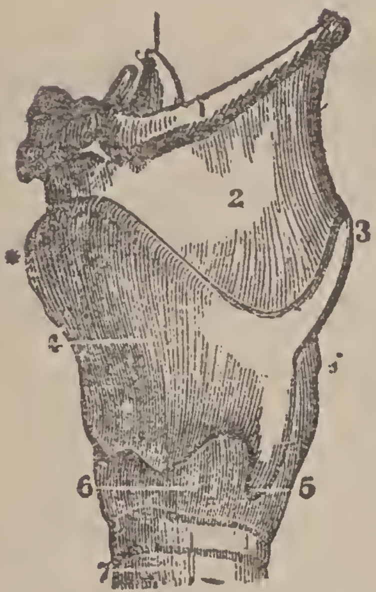

FIG. 34.

FIG. 35.

Fig. 34. A side view of the cartilages of the layrnx. *The front side of the thyroid cartilage. 1, The os hyoides (bone at the base of the tongue). 2, The ligament that connects the hyoid bone and the thyroid cartilage. 3, 4, 5, The thyroid cartilage. 6, The cricoid cartilage. 7, The trachea.

Fig. 35. A posterior view of the cartilages and ligaments of the larynx. 1, The posterior face of the epiglottis. 3, 3, The os hyoides. 4, 4, The lateral ligaments which connect the os hyoides and thyroid cartilage. 5, 5, The posterior face of the thyroid cartilage. 6, 6, The arytenoid cartilages. 7, The cricoid cartilage. 8, 8, The junction of the cricoid and the arytenoid cartilages. 12. The first ring of the trachea.

The interior of the larynx is lined with a closely adhering mucous membrane. The vocal cords composed of a highly elastic tissue are also invested

with this same kind of membrane. Lying between the true and the false cords is a depression on each side of the larynx, named the ventricle.

3. THE FUNCTIONS OF THE ORGANS OF RESPIRATION AND VOICE.

It has been learned that the lungs are filled with *bronchial tubes, air-passages and air-cells*, and, like all tissue having feeling, they contain a vast network of small blood-vessels, called *capillaries*.

The purpose of this network of capillaries (see p. 165) is to thoroughly expose the blood to the action of the air. This is accomplished: (1) By spreading the blood over a large surface; (2) Spreading it in thin streams; (3) Protecting it by merely a very delicate cover. The renewal of the blood in these capillaries is a result of the circulation; the renewal of the

FIG. 36.

Fig. 36.— Air-Cells, with Capillaries.

air in the cells is the result of *respiration.* The number of respirations is from fifteen to twenty a minute, and varies slightly, according to the age.

Venous blood absorbs oxygen in the lungs through the membranes separating it from the air, while at the same time *it parts with carbonic acid gas and watery vapor.* This influx of oxygen into, and efflux of carbonic acid gas and watery vapor out of, the blood form the most important part of the respiratory process. They purify the blood in changing it from venous into arterial, the means of purification being the peculiarly delicate membranes mentioned above. (See also page 155.) But the action of the membranes alone would suffice only for a short time, since the carbonic acid gas accumulates very rapidly, and in large quantity; and also because oxygen is needed all over the system at every instant of time. Hence we need a rapid removal of the carbonic acid gas from the lungs, and at the same time an incessant importation of fresh oxygen. We find that the clearing away of the one and the supply of the other, are accomplished incessantly by the act of *inspiration* and *expiration.* The most powerful aids in this process are the elasticity of the lungs, the mobility of the sides of the chest, and the mobility of the diaphragm. The diaphragm is a strong muscle sep-

arating the chest from the abdomen, thus forming the floor of the chest. Its special business is to assist respiration.

To avoid chilling the lungs, cold air should be inspired through the nasal passages, not through the mouth.

The inspiration of air into the lungs is effected in this way: The lungs are in close contact with the inner side of the chest-walls; the lower portion of the lungs is in close contact with the diaphragm. It is evident that whenever the chest walls move, the lungs must also move, and *vice versa*. So, when the chest expands the lungs expand; or, more properly speaking, they are enlarged by a quantity of air which rushes through the larnyx, trachea and bronchi, to fill the lungs.

In expiration the chest-walls contract; the lungs contract likewise — that is, a quantity of air is ejected from the lungs and forced to pass through the bronchi, trachea, and larynx, this being the only communication between the lungs and the external air. The act of expiration is followed by a short rest.

The widening and extending of the chest during inspiration are owing to the motion of the ribs; the

lengthening, or deepening of the chest during inspiration, to the descent of the diaphragm. *In ordinary inspiration* both chest and lungs return to the state of rest by their elasticity. Ordinary inspiration is nearly exclusively effected by the mobility of the diaphragm and the ribs. In very deep inspiration, the dimensions of the chest are increased still further by the ascent of the clavicle and the stretching of the vertebral column. Ordinarily, one breathes once to every four heart-beats, which would make eighteen breaths per minute, as there are about seventy-two heart-beats per minute.

The rhythm observable in the respiratory process is inspiration, expiration, pause; that of the heart being, in a similar manner, auricular systole, ventricular systole, pause.

Functions of the Organs of Voice.—*How voice is produced* is a simple yet interesting process. While the process of ordinary breathing is going on, there is no voice; because the vocal cords, over which the air passes to and from the lungs, are loose and inert; but when the cords are tightened, they come closer together, nearly filling up the aperture, and when very tense, the passage of the air over them sets them to vibrating, whereby sound is produced

in the same manner as the strings of an Aeolian harp will produce music by the passage of the wind over them.

When producing sound, the cords are brought within $\frac{1}{100}$th of an inch of each other. A familiar example of the *modus operandi* of voice would be seen in placing a blade of grass between the two thumbs, and then blowing through the aperture. Every youth knows how to do this.

From *physics* it is learned that the smaller, tighter, and shorter, a vibrating substance is, the higher and shriller the sound will be; so is the reverse true. Of course the number of vibrations also affect the tone.

The qualities of tone, whereby we notice a difference in the voices of persons, is probably due to the peculiar contour of the larynx, throat, and nose.

Four varieties of voice * may be mentioned; two,

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* "Voice is a sound produced in the throat by the passage of the air through the glottis, as it is expelled from the lungs. It is grave and strong in man, soft and higher in woman; it varies according to age. It is alike in both sexes in infancy, but is modified in youth; then the voice is said to 'change.' In the young woman it descends a note or two, and becomes stronger. In the young man the change is much more strongly marked. At the fourteenth or fifteenth year the voice loses its regularity, becomes harsh and unequal; the high notes cannot be sounded, while the grave ones make their appearance. A year is generally sufficient

bass and *tenor*, of the male sex, and two, *alto* and *soprano*, of the female sex. In man, there is a strong, heavy voice, as compared with the soft, shrill tones of woman.

Peculiar Forms of Breathing. — *Laughter* is an involuntary movement of the muscles of the face, indicating joy or merriment, and accompanied by deep expulsion of air from the lungs. This is due to a spasmodic action of the diaphragm. *Sobbing and crying* are due to the same causes; however, they indicate a different state of feelings. *Sneezing* is similar to the foregoing, but caused by the presence of some foreign substance in the delicate air-passages. *Sighing* is a lengthy *inspiration*, followed by an abrupt *expiration* of nearly vocalized breath.

Coughing is analogous to sneezing, differing from

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for this change to be complete, and the voice of the child gives place to that of the man. Exercise of the voice in singing should be very moderate, if not entirely suspended, while this change is going on. Voice is divided into singing and speaking voice. One differs from the other almost as much as noises do from musical sounds. It is the short duration of speaking sounds which distinguishes them from those of singing. This is proved by the fact that if we prolong the intonation of a syllable, or utter it like a note, the musical sound becomes evident." — *Le Pileur on Wonders of the Human Body.*

sneezing in the fact that the convulsive expiration drives the air through the mouth, instead of the nose, as in the case of sneezing. These irregular breathings are chiefly caused by the action of the diaphragm. *Hiccoughs* are caused by a contracted glottis and diaphragm, the noise being made by the closed glottis. *Snoring* results from the current of expired air striking against the soft palate, and causing it to vibrate.

Moaning is like sighing, but accompanied by vocalized breath. *Yawning* and *gaping* come under the same head as *moaning* and *sighing*.

Of all these vagaries of respiration, the hiccoughs are probably the most serious, as there have been cases where it was nearly impossible to stop the trouble.

4. THE AIR.

The Air We Breathe is a mixture of oxygen and nitrogen with a little carbonic acid gas and watery vapor. Of these, oxygen supplies life to the body. Yet, oxygen is so strong that the body could not bear it taken alone; hence, the nitrogen dilutes it (see page 149), while carbonic gas is present as an impurity and watery vapor to make the air less harsh. The atmosphere surrounds the earth to a

depth of 50 miles, and in a highly rarefied degree to a depth of 500 miles. Air is necessary to the growth of all organic beings, the fish and the plant as well as man.

Pure Air is essential to health. The ozone of the seashore is the purest air, having less than .4 of carbonic acid, while expired air contains 40 per cent of the same impurity. Generally speaking, the air of the country is purer than that of the city, and the air outside than that inside of a building.

How the Air is Purified by Nature is another evidence of the Creator's wisdom. All gases of varying specific gravities, when brought into contact, will diffuse, or mix, through and through; thus an obnoxious gas will be so diffused that it can do little or no harm. Every one is aware how much purer the air seems after a heavy shower. It is because it has been washed. Atmospheric air depends for its purity on being washed by rain and dew. It is heated and dried by the sun, fed with oxygen by plants, and by them also freed of carbonic acid gas. Impure air may result from (1) the want of sunlight; (2) the want of cleanliness in the household; (3) the absence of efficient ventilation; (4) the presence of dust, smoke or decaying matter. It is very dangerous to

the lungs, and although its pernicious effects upon the health are generally slow, they are nevertheless sure.

It is a wonderful fact in nature that the plants need carbonic acid gas for their growth, while they give off oxygen. This is the opposite with animals. They need oxygen to sustain life, and throw off carbonic acid gas as a waste material. Hence, it is observed that the animal and the vegetable kingdoms mutually support each other, one giving off what the other needs and one requiring what the other throws off. The Creator here laid down the great law upon which society is based, as well as that other law, *change is a law of life.*

The Changes of the Air in the Lungs have been partially discussed in a former paragraph. In an earlier topic also diffusion of gases was spoken of. By this process, the air which comes into and fills up the lungs loses its oxygen and receives in turn carbonic acid gas and watery vapor. This exchange of good for evil is due also to a property of membranes, termed *Imbibition* (endosmose and exosmose), by virtue of which fluids and gases pass through the membranes in opposite directions at the same time.

Then, to recapitulate, here is the process: The air-passages and air-cells of the lungs are filled with pure

air; the capillaries in the lining of these air-passages and air-cells are filled with impure venous blood; hence, the delicate membranes only separate the oxygen in the air and the carbonic acid gas and watery vapor in the blood. By some unknown affinity, the oxygen passes through the membrane to the blood, and the impurities of the blood pass through to the air. Then the air returns to the outer world with its load of *death*, and the now purified blood rushes back through the arteries with its load of *life*. "What a piece of work is man!"

The Difference Between Arterial and Venous Blood before and after its passage through the lungs is shown here:—

	Venous Blood.	Arterial Blood.
Color,	Dark blue,	Bright red.
Oxygen,	8 per cent,	18 per cent.
Carbonic acid,	About 24 per cent,	Less than 7 per cent.
Watery vapor,	More,	Less.
Heat,	Less,	More.
Vitality,	Less,	More.

These changes take place in the corpuscles of the blood. It might be added that the venous blood throws off an inappreciable amount of animal vapor, which gives the breath a tainted odor.

Inspired and Expired Air Differ from each other chiefly in the following points:—

(1.) Expired air has nearly the same temperature as the blood, whatever may be the temperature of the external air.

(2.) Expired air is always filled with watery-vapor.

(3.) Expired air always contains more carbonic acid gas and less oxygen than inspired air. One hundred parts of air breathed once have lost about five parts of oxygen, and gained a little less than five parts of carbonic acid. This is shown by the following statement:—

	Oxygen.	Nitrogen.	Carb. Acid.
10,000 parts of atmospheric air contain	2080	7916	4
10,000 parts of expired air contain (nearly)	1600	7916	484

The average amount of air at each respiration is about 20 cubic inches, which would make daily, counting 18 respirations per minute, about 400 cubic feet or, in other measures and computations, about 4,000 gallons. It will be readily seen that this varies with the temperature, amount of exercise, and lung capacity. Dr. Hutchinson gives the following rule: "For every inch of stature from five to six feet, eight additional cubic inches of air are given out at a forced expiration after a full inspiration."

The capacity of the lungs in a person of ordinary

size is about 320 cubic inches, although the usual breathing capacity is only about one-sixteenth of that amount, or two-thirds of a pint. Hence, it is observed that several breaths must be taken before there is a complete change of air in the lungs. This is a wise provision as the air cannot be cut off suddenly by some interference with respiration, and again it would not be healthful for the lungs and delicate air-passages to take in 300 cubic inches of air at one inspiration, especially were the air cold.

The Necessities of Ventilation are most apparent to modern civilization. The Black Hole of Calcutta, the brutal sea-captain, who shut his passengers up in a small air-tight cabin during a storm, and the more romantic case of Ginevra in the fatal trunk with the spring lock are not needed to impress the present generation with the importance of right ventilation and pure air.

Since about four hundred cubic feet of air pass through the lungs of an adult in twenty-four hours, a constant supply of oxygen — that is, of fresh air — is one of the most essential requirements of health. And since carbonic acid gas is unfit for inspiration, it follows that every inhabited room should have an open space to admit fresh air, and an open space to convey away the waste products of

respiration; both spaces must directly or indirectly communicate with the atmosphere. But the presence of a surplus of carbonic acid is less injurious than the absence of the normal amount of oxygen. A person living in badly ventilated apartments vitiates his blood, predisposes his system to disease, and thus virtually shortens his life. A total lack of air would result in speedy death.*

Ventilation is the imperceptible efflux of impure air and the simultaneous imperceptible influx of atmospheric air. It depends — (1) Upon the difference of temperature between indoors and out. Thus, in severe cold weather, a room, to be well ventilated, must be heated. (2) The quantity of

* We instinctively shun approach to the dirty, the squalid, and the diseased, and use no garment that may have been worn by another. We open sewers for matters that offend the sight or smell and contaminate the air. We carefully remove impurities from what we eat and drink, filter turbid water, and fastidiously avoid drinking from a cup that may have been pressed to the lips of a friend. On the other hand, we resort to places of assembly, and draw into our mouths air loaded with effluvia from the lungs, skin, and clothing of every individual in the promiscuous crowd — exhalations offensive to a certain extent, from the most healthy individuals; but when arising from a living mass of skin and lungs in all stages of evaporation, disease and putridity — prevented by the walls and ceiling from escaping — they are, when thus concentrated, in the highest degree deleterious and loathsome.— *Birnan.*

motion of the atmospheric air. Strong currents of air, as winds or storms, greatly facilitate ventilation. (3) The size of the orifices through which the air is expected to pass. When No. (1) fails, as e. g., in summer, we use No. (3) mostly — that is, we open doors and windows.

Draught is a perceptible current of colder *air* striking, and consequently cooling only a portion of the body, usually productive of colds.

This principle ought to obtain in ventilating rooms and houses.* Have an opening near the floor

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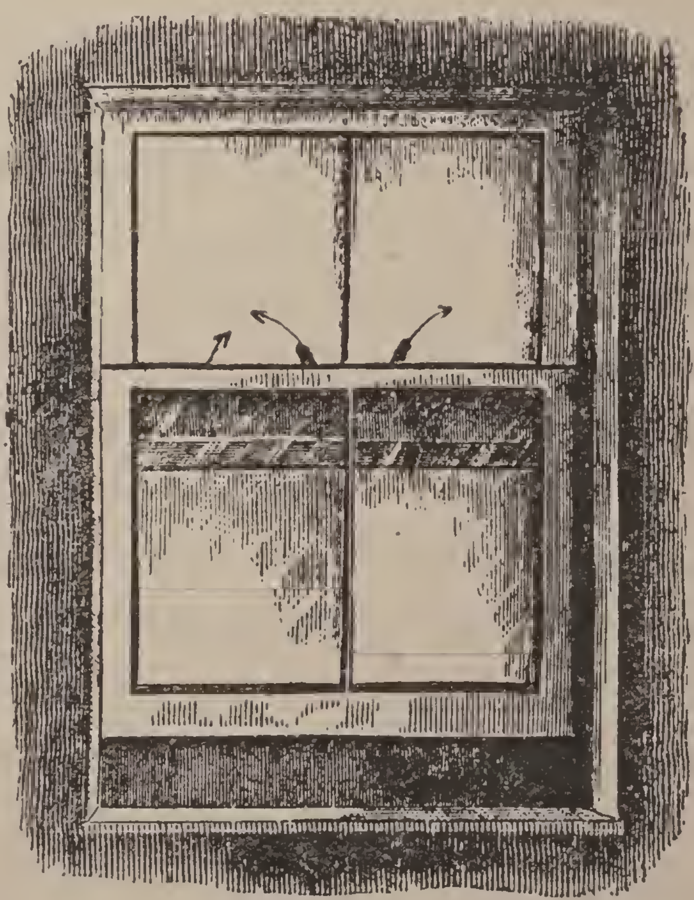

FIG. 37.
Showing manner of ventilating by inserting strip of wood beneath lower sash of window.

* When the window is of the common sash kind, a good supply of fresh air may be obtained without a current, by placing a strip of board about four inches wide under the lower sash (Fig. 37). The window is thus closed against rain and snow, but allows a supply of fresh air to enter between the sashes. If still more ventilation is needed to keep the air of the

large enough to allow the pure air to enter and the carbonic acid gas (heavier than air) to pass off; then an opening near the ceiling to allow vapors to escape and to maintain a current through the rooms, as much of the impurity has been diffused through the air in the room. Every person should have at least 2,000 cubic feet of air per hour in order to insure health, the breathing space being 600 feet. Especial care should be taken in properly ventilating sleeping apartments.

Important Facts.—In breathing, a person of average size exerts a power equal to raising a two hundred pound weight resting upon the chest. The length of time one may hold his breath can be greatly increased by breathing out all the air possible in the lungs, then take several long inspirations in order to fill the lungs with pure air. This fact is useful to know in going through smoke or fire, or in the case of diving. It is said that pearl fishers, by long practice, have been able to remain under water for three or four minutes. Ordinarily, thirty seconds are long enough to hold the breath. Every fifth breath seems to be deeper and stronger than the four preceding ones. Nearly all the blood in

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room sweet, the same arrangement may be made at the top of the window.—*Hutchison.*

the body reaches the air in the lungs every two and half minutes. The lungs daily (24 hours) throw off from eighteen to twenty-five ounces of watery vapor, and from two to three pounds of carbonic acid gas, both depending upon the temperature, exercise, age, sex, and general health. Air that contains more that $3\frac{1}{2}$ per cent of carbonic acid gas is injurious. By constant practice in taking full respirations a portion of each day, one may develop his chest measure many inches.

The parrot, magpie, and raven may be taught to speak by rote, but man alone has the power of speech proper. The range of the human voice is said to be four octaves. The wonders of the Phonograph, Telephone, and Graphophone are marvelous. What has science in store for us?

6. HYGIENE OF THE RESPIRATORY SYSTEM.

Respiration by Means of the Skin.—Through the skin of the body, oxygen of the air enters and passes to the blood; and carbonic acid gas and watery vapor emerge through the skin from the body. The quantity of watery vapor perspired in twenty-four hours amounts to about 2 pounds.

The proper supply of oxygen forms one of the three most important requirements for health. (For the other two see pp. 110 and 150.)

The Lungs Need Action as well as pure air. Hence, full inspirations fill the remotest air-cells. This can be done by raising the chin, throwing back the shoulders, and drawing in a long breath. Exhale slowly. Persons of sedentary habits should do this several times a day. Try this daily for months and note the effect.

The Injurious Effects of "wet feet," and of garments moistened from rain, or from having been worn next to the skin too long, are due to the cold produced by evaporation, and also to the greater conductive power of water. The skin must be kept warm, and free from moisture; garments worn next to the skin should be frequently changed. A person who, with his body heated from exertion or rapid motion, and perspiring copiously, should enter a colder atmosphere, or be exposed to a draught, would lose an enormous quantity of heat, both by conduction and radiation.

Diseases resulting from "colds" are among the most painful and dangerous. The process of "cooling off" should at all times be carried on slowly and gradually.

Warm Moist Air Is Best for breathing, as cold, damp air is apt to irritate the lungs. Very hot air is injurious.

The Organs of Speech need plenty of exercise in order to develop strength. Habitual practice upon the vowels, sounding them positively, will tend to strengthen the organs. The habit of saying *mornin'* for *morning* is unpardonable. Such slovenness in speech is due to laziness. Americans are more careless in this respect than Englishmen.*

SOME HYGIENIC RULES REGARDING CLOTHING, ETC.

The Normal Condition of the Body should be maintained at all times, whether the temperature of the atmosphere be low or not. This is effected (1) by clothing, (2) by the bed, (3) by buildings.

(1.) *Clothing.*— Our garments act like so many artificial skins, and thereby protect the skin from the injury which would result to it were it left exposed to the changing habits of our climate. They lose heat in place of the skin; they sustain intense cold or heat, rain and storm, in order that the delicate

* Speak the speech trippingly on the tongue.—*Hamlet.*

vessels of the skin may not be contracted by cold or expanded by heat, and the nerves not be shocked. As the garments worn next to the skin are constantly moistened by perspiration, their water-absorbing qualities should be consulted. And since moist fabrics are better conductors of heat than dry ones, such garments must be frequently changed.

Linen is a rapid absorbent of moisture. As the moisture absorbed readily evaporates, and thereby produces cold, and as linen is also a good conductor of heat, it is a favorite article of clothing in summer; but it should never be worn next to the skin.

Cotton neither absorbs as much moisture, nor conducts heat as well, as linen. It is, therefore, warmer, although much cooler than either wool or silk.

Woolen is a great absorbent, which does not give up its moisture so readily as the preceding fabrics. This property makes it very valuable. It is a bad conductor on account of the great quantity of air contained within its meshes. It also possesses the property of condensing watery vapor within its tissue, and thus produces warmth. This explains why fresh flannel, put on after great exertion, feels so

warm. It should at all times be worn next to the skin.

(2.) *The Bed.*—This is the sleeping apparel during nearly one-half of our life, and as important as clothing. It is made of material similar to that of garments and serves the same purpose. But it must be made much warmer than our clothing, because (*a*) the body develops less heat during sleep, and must yet be maintained at its standard temperature; (*b*) the body, when not lying down, is heated by currents of heated air ascending from the feet to the neck, while when stretched out horizontally the body is not so heated, for these currents then ascend perpendicularly from the body. Some one has facetiously said that there should be seven hours of sleep for a man, eight for a woman, and nine for a pig.

(3.) *Buildings.*—*Dwelling Houses* serve the same purposes as clothing, which they also resemble in this: that, as a rule, they are built of badly conducting material. Like clothing, the walls of buildings should always be permeable to air. As long as they are in good condition they are easily penetrated by atmospheric currents. This is evident, for we know that wood, brick and stone are more or less porous, and that they readily absorb water; now, wherever

water can penetrate, air, being so much lighter, can enter in hundredfold quantities; the fact that we never feel air pass through walls means nothing, since currents of air moving at a rate less than about 20 inches a second are not felt by the nerves.

Moist Walls are unhealthful for the same reasons as those applying to moist garments: (*a*) The stoppage of ventilation, the pores of the walls being taken up by water to the exclusion of air; (*b*) The cold-producing effects, owing to increased radiation and conduction to heat the water; (*c*) The cold generated by the evaporation of the moisture.

Large Quantities of Water are contained in the mortar of the walls in newly erected buildings. Most of this water must be first removed before the dwelling is fit to be inhabited. It is removed best by giving it sufficient time to evaporate, and promoting the evaporation by means of artificial heat and by removing the vapor by ventilation.

REVIEW QUESTIONS.

1. Have you read Holmes' *The Living Temple*?

2. What system deals with the blood, its travels, etc.?

3. Where are the air and the blood brought into close contact?

4. What are the offices of respiration? What does man require aside from food in order to live?

5. Give the composition of air. For what purpose is nitrogen?

6. What is the temperature of the human body? What would a decrease of five degrees F. of animal heat produce?

7. Give one of the most important requirements of health.

8. In what three ways may heat be lost? Explain each?

9. Why is a wooden handle put upon an iron poker? Why should wet clothing be changed at once?

10. Why do we "catch cold" more easily in moist, cold weather than in dry and cold?

11. Name the "Organs of Respiration." Which may also be considered organs of voice?

12. What are the two kinds of blood? Where does the blood change from impure to pure?

13. Describe the lungs. Through what passage do they receive air?

14. Describe the bronchial tubes. In what do they end?

15. What are the *cilia*? Give their purpose.

16. With what are the air-cells lined? What are capillaries?

17. Locate and describe the trachea. From what may a good idea of the trachea be obtained?

18. Give a general description of the larynx.

19. Give structure of the pleura. Why does it seem so smooth?

20. Explain the relation of trachea and the bronchi.

21. Name the muscles of respiration. What is the chief one?

22. Name the organs of voice. What one was given under organs of respiration?

23. Name the parts of the larynx. What is Adam's Apple?

24. Describe briefly each cartilage forming the larynx.

25. What is the purpose of the vast net-work of capillaries in the lungs?

26. What is the most important part of the respiratory process?

27. Why must the carbonic acid gas be removed rapidly?

28. How may one avoid chilling the lungs?

29. Explain fully the process of inspiration. Of expiration.

30. What is the rhythm in the respiratory process? Of the heart?

31. How is voice produced? How do the vocal cords produce sound? Explain the example of the blade of grass and the thumbs.

32. How many varieties of voice are there? State what is quoted from "Le Pileur on Wonders of the Human Body."

33. Name the peculiar forms of breathing, giving the cause of each.

34. What is air? Give its composition, and depth upon the earth.

35. What is the purest air? How does nature purify the air?

36. What are the changes which air undergoes in the lungs?

37. Give the table showing differences in venous and arterial blood. Also, the table showing how inspired and expired air differ from each other.

38. Give the amount of air at each breath. How much air is used in 24 hours? Give Dr. Hutchinson's rule.

39. What is the capacity of the lungs? How long does it require for the lungs to be fully refilled?

BLACKBOARD OUTLINE.

VI. THE RESPIRATORY SYSTEM AND VOICE.

1. **The Introduction.**
   - a. Uses of Respiration.
   - b. Relation of Circulation and Respiration.
   - c. Composition of Air.
   - d. Animal Heat and Bodily Temperature.
   - e. How the Heat of the Body May Be Maintained.
   - f. Heat May Be Lost By
     - Conduction,
     - Radiation,
     - Evaporation.

2. **The Organs of Respiration and Voice—Their Structure.**
   - a. General Discussion.
   - b. The Organs of Respiration and Voice.
     - Of Respiration
       - The Lungs,
       - The Air Passages,
       - The Pleura,
       - The Larynx,
       - The Trachea,
       - The Bronchi,
       - The Muscles.
     - Of Voice.
       - The Larynx,
         - 2 Arytenoid,
         - 2 Cuneiform,
         - 1 Cricoid,
         - 1 Thyroid,
         - 1 Epiglottis.
       - The Vocal Cords,
       - The Muscles.
   - c. The Structure of Same.
     - Of Respiration.
     - Of Voice.

3. **The Function of the Organs of Respiration and Voice.**
   - a. Of Respiration.
   - b. Of Voice.
   - Peculiar Forms of Breathing.
     - Laughter,
     - Sobbing and Crying,
     - Sneezing,
     - Sighing and Moaning, etc.

4. **The Air.**
   - Amount of Atmosphere,
   - Pure Air — How Made,
   - The Change in the Lungs,
   - Difference Between Venous and Arterial Blood as Produced by the Effect of the Air,
   - Tables of Comparison,
   - Capacity of the Lungs, Number of Respirations per Minute, etc.,
   - The Necessities of Ventilation.

Important Facts.

5. **Hygiene of the Respiratory System and Voice.**
   - a. Hygiene.
     - Respiration Through the Skin,
     - Lungs Need Action,
     - The Injurious Effect of Wet Feet,
     - Warm, Moist Air,
     - The Organs of Speech,
     - Rules Regarding Clothing and Shelter

VII.

THE DIGESTIVE SYSTEM.

Some will have it that the stomach is a mill; others that it is a fermenting vat; and others that it is a stewpan; but in my view of the matter, it is neither a mill, a fermenting vat, nor a stewpan, but a stomach, a stomach!—Sir John Hunter.

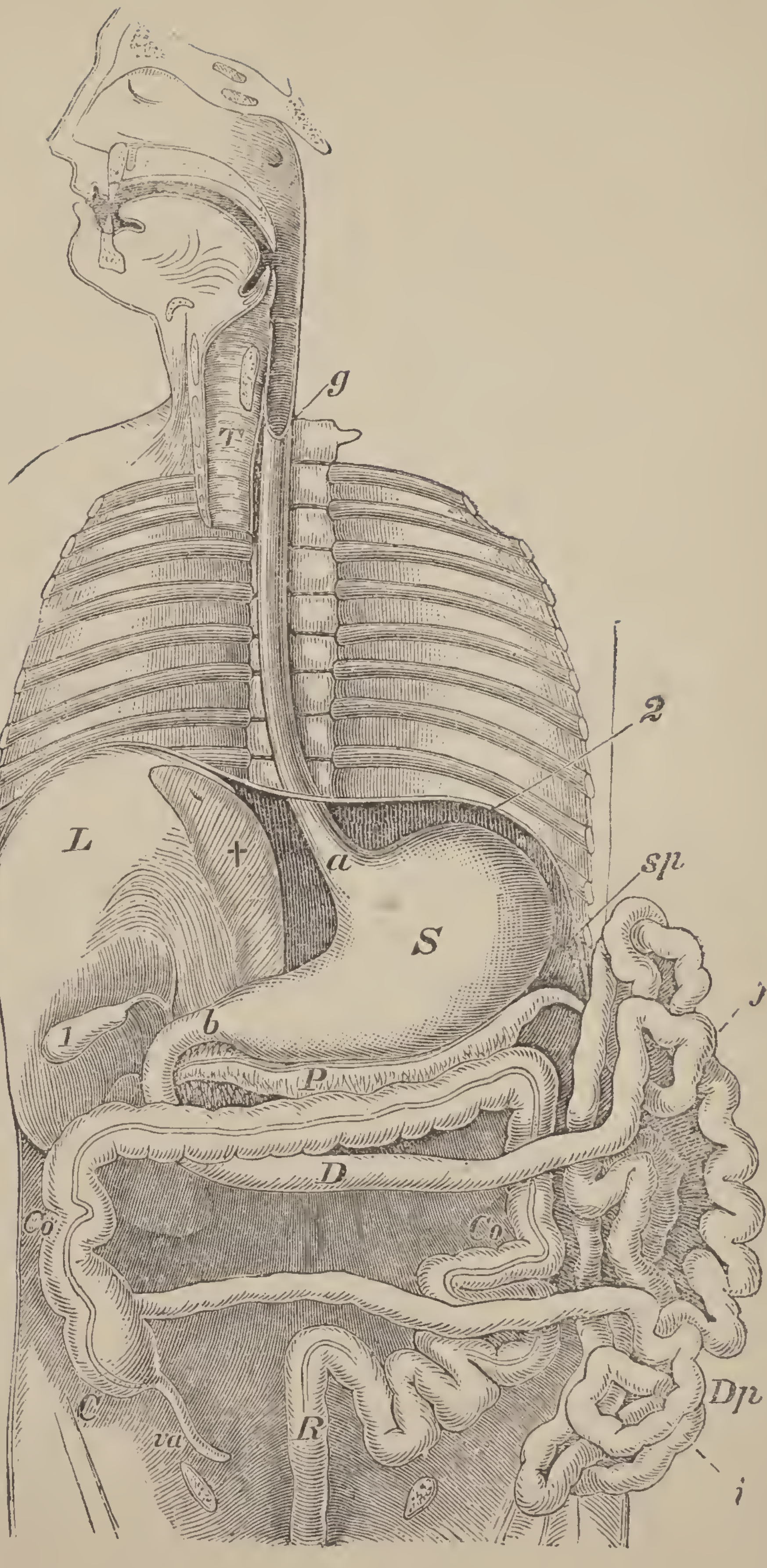

FIG 38.

THE DIGESTIVE APPARATUS (HENLE, ANAT.).

Front View — Head and Neck turned toward the right.

T Trachea.
g Oesophagus, Gullet.
a Cardia.
S Stomach.
b Pylorus.
P Pancreas.
D Duodenum.
Dp Small Intestines laid aside.
Jejunum.
Ileum.

† Left Lobe of Liver cut off.
C Cæcum.
va Vermiform Appendix.
Co Colon.
R Rectum.
L Liver.
1 Gall Bladder.
2 Diaphragm.
sp Spleen.

VII. The Digestive System.

1. INTRODUCTION.

The Human Body is a machine, wnose parts are so nicely designed and fitted that were the proper care taken it would work on through man's allotted span of "three score and ten," and yet not be "run down." In all its varied movements and manifold motions of its different parts, together with its great number of functions, the body is supported and maintained by an energy, whose source is *food*, physically and chemically prepared to give power and action to this living, moving, working machine. No human contrivance, no matter how nicely and perfectly adjusted in all its parts, works so smoothly, silently, and harmoniously, with such precision and completeness, as the human organism, which is indeed "fearfully and wonderfully made." Hence, from the moment it enters the mouth to begin its preparation to become the force, that supplies the energy that fells a tree or brings into being a law of gravitation, to that supreme moment after

it has passed the mysterious laboratories of the body, — the following pages will consider *food* under the broader subject of *the digestive system.*

The Food of Plants requires no modification previous to its being absorbed by the vegetable organism. Plants feed principally on water, carbonic acid, ammonia, and saline substances, all of which they find ready for their absorption. Man and animals, however, derive their food principally from organic substances. They prepare it within their bodies before it is absorbed by the blood; and man, in addition, cooks his food.

The Changes Wrought Upon the Food in the body may be divided into three parts: (1) *Digestion*, or the proper preparation of food in the alimentary canal so as to fit it for absorption. (2) *Absorption* and *Assimilation*, or the conversion of food into blood and tissue. (3) *Excretion*, or the decomposition of food and its removal from the body. With the exception of the lungs, which absorb oxygen, the alimentary canal is generally the only channel by which food can pass into the blood.

2. THE ORGANS OF DIGESTION.

The Organs of Digestion are *the Mouth*, *Teeth*, *Salivary Glands*, *Pharynx*, *Oesophagus*, *Stomach*, *Intestines*, *Lacteals*, *Thoracic Duct*, *Liver*, *Gall-cyst*, *Pancreas*, and *Spleen*.

The Kidneys may be classed here, although they do not belong to the *Digestive System*.

3. THEIR STRUCTURE.

The Mouth (see page 198, Fig. 38) is the irregular cavity, containing the organs of mastication and taste. It is the mill in which the food is ground. In fact, it is the preparation room for the material soon to pass through the oesophagus to the chemical work-shops of stomach, intestines, etc., on into the blood.

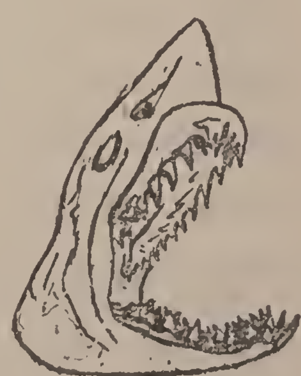

FIG. 39.
Jaws of a Fish.

The Teeth (page 26, Fig. 6) are the bone-like bodies implanted in the upper and the lower jaw.

While the structure of the teeth belongs to a previous chapter, it may be interesting here to refer to the adaptation of teeth in different

classes of animals to the food upon which the animal subsists. Thus, in fish, the food is swallowed entire; hence, the teeth have, as a rule, the form of sharp, curved spines (Fig. 39). Such teeth merely serve the purpose of retaining or holding the prey. The horse has incisors in both

FIG. 40.

Skull of a Horse.

jaws (Fig. 40), while herbivorous animals of the ruminating order have their incisors only in the lower jaw. These incisors merely serve to cut off the grass or herbs upon which the animal feeds. The process of mastication is performed entirely by the molars, the canines being either wanting or only imperfectly developed. Carnivorous animals, such as the bear or dog, have incisors for dividing the food, canine teeth for attacking and re-

taining the prey, and molars for grinding (Fig. 6). In man the teeth are so selected as to combine the features of those of the herbivorous and the carnivorous animals, which distinctly points to the fact that his food should be composed both of animal and vegetable substances.

The Salivary Glands are six in number, two *parotids*, two *submaxillaries*, and two *sublinguals*, there being three on each side of the lower jaw. The largest of these are the two *parotids*, which lie, one on each side, just back of the angle of the jaw and directly in front of the external ear. These glands are affected in mumps. The ducts from the parotids, one from each, reach the mouth, opposite the second molar of the upper jaw.

The *two submaxillary glands*, one on each side of the lower jaw, are situated just in front of the angle of the lower jaw, and their ducts, one from each, enter the mouth by the side of the *frænum linguæ*. or the bridle of the tongue.

The sublingual glands, also two in number, are situated in the floor of the mouth, one on each side of the *frænum linguæ*. These glands have several ducts opening into the mouth.

The *Salivary Glands*, together with the *Mucous Glandules* in the mucous lining of the mouth, produce fluids whose uses in digestion will be clearer later on. They are made up of bunches of small pouches, covered with a network of blood-vessels.

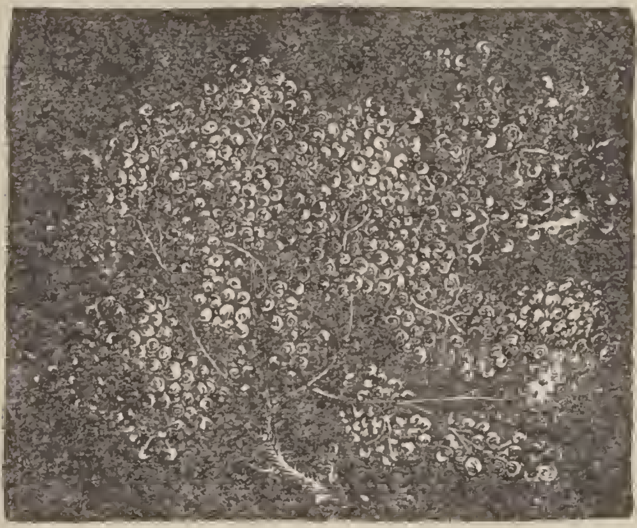

FIG. 41.
Structure of a Salivary Gland.

The Pharynx is the short cylindrical cavity between the mouth and the oesophagus. Passages enter the pharynx from the mouth, the ears, the nostrils, and the lungs. It is made up of muscular fibre running in two directions. The pharynx is to the *oesophagus* what the larynx is to the *trachea*.

The Oesophagus, or gullet, is a large membranous tube that extends behind the trachea, the heart, and the lungs, passes through an opening in the diaphragm, and terminates in the stomach by the cardiac orifice.

The Stomach is the principal organ of digestion, and serves for the solution and digestion of the food

into chyme. It is situated in the left side of the abdomen immediately below the diaphragm, inclining obliquely downwards from the left to the right. It has two openings: one connected with the oesophagus, called the *cardiac orifice*, which is always open; the other connected with the upper portion of the small intestine, called the *pyloric orifice*, which is firmly closed so as to allow only the finest pulp to pass. It is provided with a multitude of small glands, in which is secreted the *gastric juice*. The stomach is the continuation of the gullet, but it is much wider, and of different forms in different animals. It is a sort of bag of about one and a quarter square feet interior surface, with a capacity of four pints, and a weight of seven ounces, in the adult man.

The stomach has three coats: the exterior, known as the *serous* coat, is very strong, and invests every part of the organ; the middle, or *muscular* coat, is composed of two layers of fibres, one set of which is arranged circularly, and the other longitudinally. The interior is the *mucous* coat, and is arranged in folds, called *rugæ*.

The Intestines are divided into the *small* and the *large;* the former being about twenty-five feet in length, and the latter about five feet. They are each subdivided into three parts, with the names of *duode-*

num, *jejunum*, and *ileum* for the small; and *cæcum*, *colon*, and *rectum* for the large.

The *intestines* (Fig. 38) are the continuation of the stomach. They form a long, narrow tube, which,

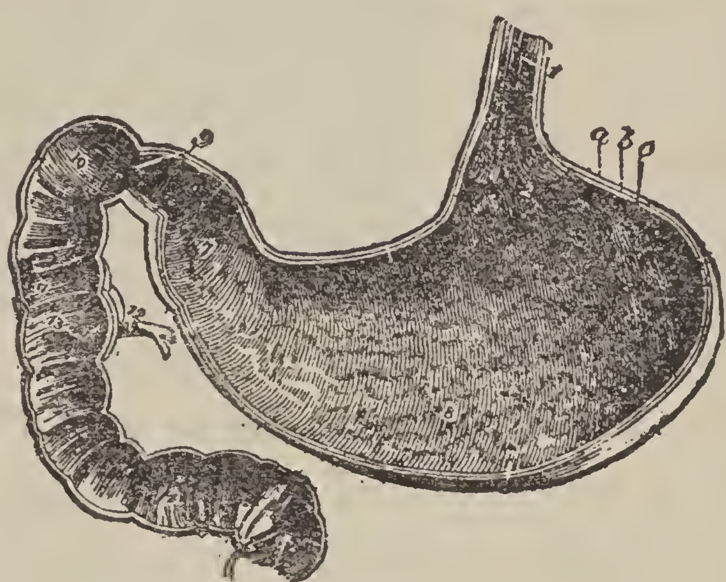

FIG. 42.

THE INNER SURFACE OF THE STOMACH AND DUODENUM.

1. The lower portion of the œsophagus. 2. The opening through which the food is passed into the stomach. 8. The stomach. 9. The opening through which the food passes out of the stomach into the duodenum, or upper portion of the small intestine. 10, 11, 14. The duodem. 12, 13. Ducts through which the bile and pancreatic fluid pass into it. *a*, *b*, *c*, the three coats of the stomach.

like the stomach, is composed of membranous, muscular, and mucous coats. The intestines are of different lengths in different orders of animals.

The *alimentary canal* begins with the mouth and

terminates with the rectum. Its entire length is 400 inches, nearly, of which about 240 inches belong to the small intestine. The small intestine has many windings, is indirectly attached to the spinal column, and fills the lower central portion of the ventral cavity. The order of its parts is: duodenum, D, jejunum, j, and ileum, i, which are one, nine, and fifteen feet in length, respectively.

The small intestine possesses a regular motion in the direction of its own course; this motion is called *peristaltic*, and consists of muscular contractions, such as take place in the gullet, the purpose of which is, to propel the food onward to the lower parts and into the large intestines.

The *duodenum*, sometimes called the second stomach on account of the digestion taking place in it, is so called from its being about twelve finger lengths long. It begins at the pyloric orifice of the stomach and extends backwards and upwards until it ends in the *jejunum*. The *jejunum* also has the three coats, which are slightly pinkish in color, the mucous membrane being thicker than in any other of the intestines. The jejunum is so called from a French word meaning "empty," as that is the condition in which this intestine is always found after death.

The *ileum*, meaning to twist, is the third section of

the small intestine, and is darker in color than the other divisions.

The *large intestine*, about five feet long, is shorter but wider than the small intestine. It has three subdivisions: the *cæcum*, C, the *colon*, Co, and the *rectum*, R. They are respectively three inches, four feet, and seven inches in length, these varying in different individuals. The cæcum, which has a grayish blue color, is the short portion below the junction of the small intestine (the connection being made by a valvular arrangement allowing the food to pass into the cæcum from the ileum), and distinguishable by a vermiform appendix, *v*, *a*, about three inches in length. The continuation of the cæcum forms the colon, meaning "to prohibit" as the food passes slowly through this portion, which rises on the right side of the abdomen up to the liver. This portion of it is the *ascending colon.* The colon then suddenly turns at a right angle and crosses over to the left side of the body; this horizontal part of it is called the *transverse colon;* finally, it makes a sudden turn downward and backward along the left side of the body, where, accordingly, it is called the *descending colon*, which is succeeded by the rectum, R, meaning straight, owing to its position. The large intestine is readily recognized by its width, its stretching capac-

ity, and its many folds and pouches. Its motions are far slower than those of the other intestine, and scarcely ever result in actual displacements of the parts with reference to each other, such as take place in the small intestine.

The Omentum, or Caul, is the serous membrane of four layers, enveloping the viscera of the abdomen, protecting them from cold and violence. It is the folds of the peritoneum.

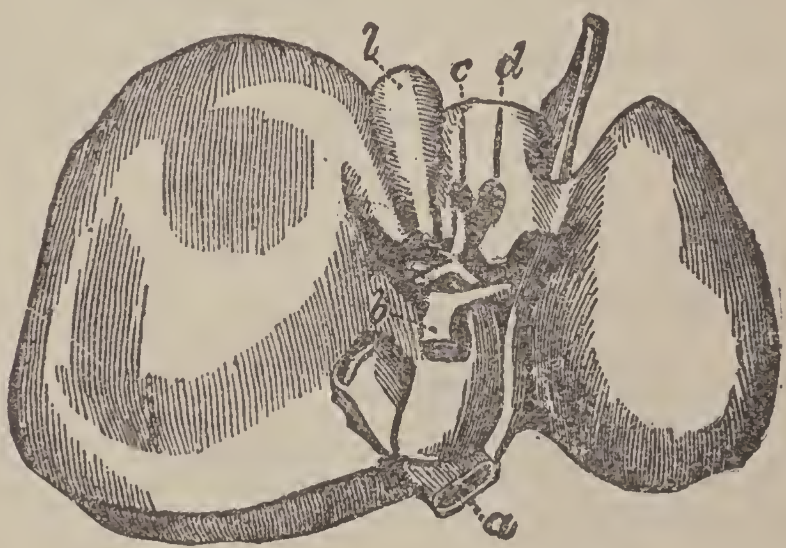

FIG. 43.

THE LIVER TURNED UP AND VIEWED FROM BELOW.

a, Vena Cava. *b*, Vena Portæ. *c*, Bile Duct. *d*, Hepatic Artery. *l*, Gall Bladder. The termination of the Hepatic vein in the Vena Cava is not seen, being covered by a piece of the Vena Cava.

The Liver is a large dark, red-colored glandular body (covered by a coat of peritoneum), the largest

organ in the system, and weighs about four pounds and measures twelve inches in its longest diameter. It is situated toward the right side of the abdominal cavity, and is retained in its place by several ligaments. It is composed of five lobes which in turn are divided into smaller bodies, or lobules, about the size of cabbage seeds, each lobule containing an artery, veins, and a net-work of ducts. Its upper surface is convex and its under concave. It performs the double office of separating impurities from the venous blood and of secreting bile. On the under surface of the liver is a membranous sac, called the gall-bladder, which is the reservoir for the bile.

The Gall-cyst (Fig. 43) is a small membranous sac, upon the under surface of the *liver*, containing about two ounces, and receiving the bile from the net-work of ducts in the liver. It has a passage to the duodenum, called the *bile-duct*.

The Pancreas ("all flesh") **and Spleen are glands** of the same system, both having their share in the process of digestion. The *pancreas* is a long, flattened gland, about seven inches in length, weighs three or four ounces, and is situated transversely across the posterior wall of the abdomen, immediately behind the stomach. It has the lobular structure

similar to the liver; but each lobule is made up of smaller lobules. The secretion of this gland passes through its duct into the duodenum.

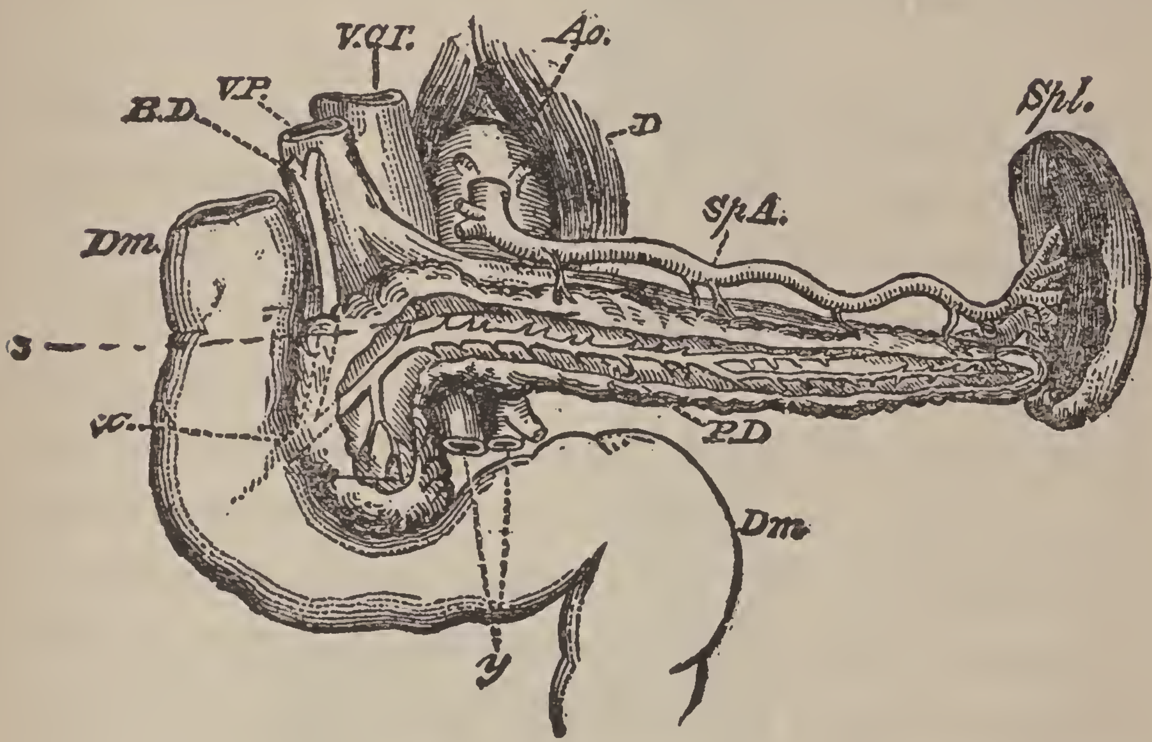

FIG. 44.

SPLEEN AND CONNECTING ORGANS.

The Spleen, *Spl.*, with the Splenic Artery. *Sp. A*, Below this is seen the Splenic Vein running to help form the vena portæ, *V. P. Ao.*, the Aorta. *D.*, a pillar of the diaphragm. *P. D.*, the Pancreatic Duct exposed by dissection in the substance of pancreas. *Dm.*, the Duodenum. *B. D.*, the Billiary Duct uniting with the pancreatic duct into the common duct, *x*, *y*, the Intestinal Vessels. *Ps.* Pancreas.

The Spleen (Fig. 44) is an oblong, flattened organ, situated in the left side close to the diaphragm, stomach, and pancreas. It has a dark bluish color, with an abundance of blood, but, unlike the liver

and pancreas, it has no duct. Its use has long been an object of conjecture although it is now supposed to have something to do with the white corpuscles of the blood.

The Lacteals.— *The Lacteals* are minute vessels, which commence in the villi, upon the mucous surface of the small intestine, beginning like the small veins and acting as absorbents. From the intestine they pass between the membranes of the *mesentery* to small glands about the size of peas which they enter. The first range of glands collects many small vessels, and transmits a few larger branches to a second range of glands; and, finally, after passing through several successive ranges of these glandular bodies, the lacteals, diminished in number and increased in size, proceed to the enlarged portion of the thoracic duct, into which they open at or about the last dorsal vertebra. They are numerous in the upper portion of the small intestine.

The Thoracic Duct commences in the abdomen, by a considerable dilatation. From this point, it passes through the diaphragm, and ascends to the lower part of the neck keeping close to the spinal column and sometimes for an inch or two separating into two ducts, then uniting again. At the lower part of the

FIG. 45.

A PORTION OF THE SMALL INTESTINE, LACTEAL VESSELS, MESENTERIC GLANDS AND THORACIC DUCT.

1, The intestine. 2, 3, 4, Mesenteric glands, through which the lacteals pass to the thoracic duct. 5, 6, The thoracic duct. 7, The point in the neck where it turns down to enter the vein at 8. 9, 10, The aorta. 11, 12, Vessels of the neck. 13, 14, 15, The large veins that convey the blood and chyle to the heart. 16, 17, The spinal column. 18, The diaphragm (midriff).

neck, it makes a sudden turn downward and forward, and terminates by opening into a large vein, called the left *subclavian*, which passes to the heart. The thoracic duct is equal in diameter to a goose-quill, and, at its termination, is provided with a pair of semi-lunar valves, which prevent the admission of venous blood into its cylinder.

The lacteals and thoracic duct have three coats.

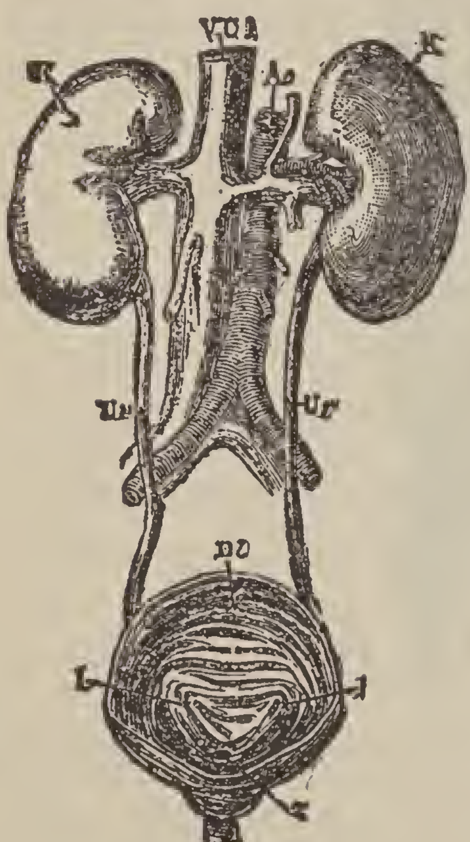

FIG. 46.

KIDNEYS, URETERS AND BLADDER.

K, the kidneys; *Ur.*, ureters; *Ao.*, aorta; *V. C. I.*, vena cava inferior, and the renal arteries and veins. *Bl.*, the bladder, the top of which is cut off so as to show the openings of the ureters (1, 1) and that of the urethra (2).

The Kidneys are the two bean-shaped bodies about five inches long, two and a half inches wide, and one inch in thickness. They are reddish yellow in color, and are situated in the lower part of the back, one on each side of the lumbar region of the spine. From the middle of the concave side of each kidney, a long small tube, the *ureter*, proceeds to the bladder. The latter, situated in the pelvis, is an oval bag, the walls of which contain abundant unstriped muscular

fibre, while it is lined, internally, by mucous membrane and coated externally by a layer of the peritoneum, or double bag of serous membrane, which has exactly the same relations to the cavity of the abdomen and the viscera contained in them, as the pleuræ have to the thoracic cavity and the lungs. The ureters open side by side, but at some little distance from each other, on the posterior and inferior wall of the bladder. A single aperture leads into the canal, which is called the *urethra*, by which the cavity of the bladder is placed in communication with the exterior of the body.

4. THE PROCESS OF DIGESTION.

Since the *location* and *structure* of the organs of digestion have been fully set forth, the various transformations, or steps, through which the food passes from *mastication* to *assimilation*, will be the logical order of arrangement, and the whole process takes place in the alimentary canal, where the food is subjected to the action of two forces, one *physical* and the other *chemical*, whose useful and final effects will be discussed in the present topic — *The Process of Digestion*.

Digestion Begins in the Mouth, where the food is thoroughly chewed, crushed, and ground by the

teeth (see p. 26), which are assisted in this work by the tongue and cheeks.

The tongue has the function of holding back the portion of aliment which is about to pass down not yet wholly crushed by the teeth; and any particles of food which have been pushed outside of the teeth are thrust back again under the teeth by the compression of the lips and cheeks. The tongue also crushes soft substances against the palate. It is, at the same time, an organ invested with special mobility and acute sensibility, so as to pass judgment upon the qualities, situation, and degree of trituration of the aliment in the mouth. The combined action of the teeth, tongue, lips, and cheeks results in the breaking down of the food. The purpose of this is, that the food shall present a large surface to the dissolving action of the various fluids acting upon it. If large masses were to pass down unbroken by the teeth, they would scarcely be altered in the stomach, and consequently supply nutrition imperfectly.

In *chewing* the lower jaw does the chief part of the work, as the upper has little motion, being only a point of resistance. These motions might be classed as up-and-down, or *cutting;* a side, or *grinding*, and backward and forward, or *gnawing*. This reduction of the food to a fine condition is called *mastication.*

Insalivation, or the Mingling of the Saliva with the food during the process of *mastication*, may be termed the second step in this digestive process. In another portion of this chapter, the salivary glands were discussed. Now, these glands as well as the mucous lining of the mouth secrete a colorless, frothy, watery-like fluid, called *saliva*, which has the peculiar property of changing *starch* into *sugar*, while air, contained in the bubbles of the saliva, is also mingled with the food. Saliva is alkaline in its nature; contains *ptyalin*, which is the active principle that converts the starch into sugar. The amount of saliva daily secreted is about five pounds.

The presence of food in the mouth, or even the smell or taste of the same, will excite the salivary glands, causing them to act.

Too much stress cannot be laid upon thorough mastication and insalivation; for only during these steps and that of *deglutition* is the food under man's control, and the ease of digestion depends upon the first two steps. In short, the uses of saliva may be summed up as follows:—

(1.) To soften the food so that the gastric juice will attack it more readily.

(2.) To aid articulation and taste by keeping the mouth moist.

(3.) To quench thirst.

(4.) To facilitate mastication and deglutition by moistening the food.

(5.) To change the starch of the food into sugar, thus fitting the food for digestion.

Deglutition, or the Act of Swallowing — the third part of digestion — takes place after the aliment, by means of mastication and insalivation, has been reduced to a minute pulp, and is passing it from the mouth through the œsophagus, or gullet, to the stomach. When the food has been thoroughly reduced and mixed with saliva, it is placed upon the rear of the tongue, from which it is forced into the *pharynx* where it is seized by other muscles, and rapidly moved past the glottis into the œsophagus. This downward passage is effected by a successive contraction of the muscular parts around the œsophagus above the food, while they are lax below. Hence it is that a man can drink standing on his head; and a horse with its head lower than its stomach. Food, while in the mouth, is controlled by the will, but deglutition is not.

The Oesophagus secretes an oily fluid that keeps its surface well lubricated. As soon as the food enters this passage, it is forced on into the stomach by the

alternate contraction and relaxation of the rings of the gullet, which have been described elsewhere. The food now passes from the cardiac orifice into the stomach, where its changes will next be considered.

The Stomach Digestion is the fourth step in this process. As soon as the food reaches the stomach, the gastric juice, a clear, colorless, acid exudation from millions of minute tubes in the inner walls of the stomach, begins to flow and to moisten the mucous membrane of the stomach, thoroughly mixing with the food which is thrown from side to side, round and round, by the alternate contraction and relaxation of the middle coat of the stomach.

This muscular coat is made up of involuntary muscles; it is these which perform the mechanical labor of kneading and rolling about the pulp. The food is pushed on along the great curvature of the stomach (on the left side of the body) to the right, and thence to the left along the lesser curvature. The continual rolling motion, called the *peristaltic* motion, together with the continual addition of gastric juice, finally reduces the food to a fine pulp of a consistency somewhat like that of thick soup, and is called *chyme*. The reduction of food to chyme is called *chymification*. The stomach is not capable of great muscular effort; hence it cannot crush, *e. g.* an

entire grape. The violence of abdominal motion in vomiting is not due to the effort of the stomach alone, but to the co-operation of abdominal muscles.

The interior coat of the stomach contains a great number of glands which open upon its surface. Some of these are in the vicinity of the pylorus, and secrete a mucous substance which covers the interior surface of the stomach, and serves to envelop undigested pieces of food so as to facilitate their passage through the intestines. The others, which form by far the greater number, secrete the gastric juice. This fluid has an extraordinary solvent power on albuminous and other substances; one part of it in 60,000 parts of water will be sufficient to exert this power. It does not act upon fatty substances further than liquefying them. It is readily precipitated by alcohol; this may explain the pernicious effect upon the stomach, caused by the use of alcoholic drinks.

The gastric juice has three properties: the acid, the fermentative, and the antiseptic. The acid dissolves different food materials; the fermentative, due to a peculiar property termed *pepsin*, produces lactic fermentation, while the antiseptic prevents putrefaction. The albuminoids (the fats and sugars being only slightly affected) which are affected by the gastric juice, are transformed into a product termed

albuminose (chyme), which, with water, salt, and fruit sugar is readily absorbed by the blood-vessels of the stomach. The remainder of the unabsorbed and undigested albuminose passes the *pylorus*, "gate-keeper," into the duodenum, where it is mixed with the *bile* and the *pancreatic* juice. The food undergoes its most important changes in the stomach. The stomach daily secretes nearly fifteen pounds of *gastric juice*. Much of it, if not all, is reabsorbed by the walls of the stomach after its duty is done.

Chyme, as it leaves the stomach, is composed of —

(1) Albuminous matter, broken down, partly dissolved, partly dissolving, and, it may be, partly undissolved.

(2) Fatty matter, broken down, but not dissolved.

(3) Starch, being slowly converted into sugar, and as fast as it becomes sugar, dissolving in the fluids of the mixture.

(4) Gastric juice, mixed with substances 1, 2, 3, and liquids, and such portions of aliment as are undigestible.

Chief Functions of the Stomach: (1) To mix all food into a pulp; (2) To dissolve the nitrogenous

portion of the food by means of the gastric juice. The conversion of starch into sugar, which takes place in the mouth, is in the stomach discontinued temporarily, but not suspended, as will be seen further on.

Conditions Favorable to Stomach Digestion.— The following are among the most important: 1. A temperature of 100° F., nearly. Any reduction, such as results from overdoses of water or ice cream, may lead to serious results. When a substance, instead of being digested in the stomach, is digested in the intestines, the time required is vastly greater.

2. Continual motion of the walls of the stomach to permeate the food with gastric juice.

3. The removal of such portions of the food as are thoroughly digested. This brings the remainder into better contact with the gastric fluid.

4. Perfect mastication and insalivation of the aliment previous to its entrance into the stomach.

5. A moderate quantity of food. The stomach should not be distended.

6. Regular intervals between any two consecutive meals. They should be long enough for the food of one meal to have left the stomach before the next is introduced.

7. No severe physical or mental exertion either immediately before or after a meal.

8. A tranquil mind.

9. Bodily health.

10. Favorable weather.

The Intestines furnish the fifth step in the course of digestion. When the food, digested and undigested, under the name of *chyme* passes the pylorus it enters the duodenum to undergo another change. About three inches from the entrance to this intestine a new digestive fluid reaches the food by a small duct. It is formed of two fluids, the *bile* from the liver and the *pancreatic* juice from the pancreas.

The Bile is a greenish-yellow, very bitter alkaline liquid with a peculiar smell, secreted by the liver (*L*, Fig. 38). The liver (1) secretes bile, and (2) modifies sugar for purposes which this has to serve. Bile contains waste materials which it has taken from the blood; it must, therefore, be conducted out of the system. If prevented from entering the duodenum, it congregates in the blood, producing jaundice, and acting then as a poison. Should some of it happen to be thrown into the stomach, digestion there would cease at once; nausea and vomiting, the usual bilious symptoms, would occur.

It acts also as a solvent of the fatty portions of food, and as a stimulant to the action of the intestines. Chyme, after its union with bile and the pancreatic juice, is usually called *chyle*. The process being called *chylification*.

The Pancreatic Juice is a clear, colorless liquid, distinguished (1) by its great capacity for digesting fats after they have become fluid by the warmth of the stomach; (2) by its dissolving albuminous substances. It is secreted at the rate of six ounces a day by the pancreas, *P*, an organ about seven inches long, having the form of a bunch of grapes, and generally resembling the salivary glands of the mouth. This juice also enters the duodenum. It has three ferments; *pancreatin*, which changes starch into sugar; *trypsin*, which dissolves the remaining albuminoids, and a third which partially acidifies the fats, and which has not yet been named. The salivary glands and the pancreas are readily influenced by the nervous system; thus, the sight, or smell, or the mere thought of food may prompt the salivary glands to pour saliva into the mouth, or, in common language, cause "the mouth to water."

The Intestinal Juice, a thin fluid, is secreted from minute glands on the interior surface of the small

intestine; its business seems to be to digest albuminous matter which has escaped the action of the gastric juice. The main office of the small intestine is to digest fat and to complete digestion by finishing the action of all previous fluids. Intestinal juice is also secreted from the colon. With the final action of the intestinal juice digestion is completed while absorption and assimilation begin in order to make the food a part of the blood.

The quantity of these five liquids generated daily has been estimated at 22 pounds, nearly, of which that of the gastric juice amounts to about 15 pounds. It is plain that their office is to dissolve the food and act chemically upon it. Each of them seems to have its special function, and yet none is exclusively directed to one object. They all aid one another, and are in turn assisted by the peristaltic motion of the intestines, which thoroughly mixes the food with them, and propels the chyle from above downward through that portion of the alimentary tube which succeeds the stomach. The undigested masses collect in the rectum to be properly removed.

Absorption and Assimilation. — *Chyme and Chyle* are merely digested food. Both are in the alimentary tube; one is in the stomach, the other

in the intestines. As yet they are strangers to the system — that is to say, they do not form part of it.

The oxygen of the air which enters the lungs rapidly burns up the particles of waste tissue which are thrown into the lungs by the venous blood. Now, this waste matter must be replaced by fresh particles, else the vital processes speedily cease. In other words, at every instant of life a quantity of animal tissue is dying, and must at the next instant be replaced. If no freshly-digested food is at hand, as during disease, the burnt up particles of the body are replaced, first, by the fat of the tissues, and hence the sunken appearance of the eyes and cheeks; or next, by the flesh of the tissues themselves, which results in emaciation, and finally in death, unless a cure can be effected. Thus, death and life are intimately associated and dependent upon each other in the living organism.

The question now arises: How is the digested aliment converted into blood so as to be distributed in this form over the entire body and to replace waste matter — in fact, to furnish the material for the growth and maintenance of the body? The answer is: The chyle throughout the course of the alimentary canal is taken up by capillaries and special minute vessels, called chyle-vessels or lac-

teals, and conveyed into the circulation at large. With the aid of respiration, it is then made into nourishing blood. The process of taking up the chyle forms part of the process of absorption.

Absorption.— The object of this process is, (1) to supply the blood with fresh materials; (2) to remove such particles as have accomplished their mission in the body. Absorption, then, has a two-fold character; it absorbs essentials from *without* the bodies and carries them to the blood; it absorbs waste materials from *within* the system and conveys them outside the body. Absorption is mainly carried on by two distinct sets of vessels, viz., *blood-vessels*, or capillaries, and *lacteals*, or lymphatics, also called absorbents. The former are abundantly spread over the interior surface of the stomach, and both the small and large intestines; the latter only in the intestinal canal, but most numerously in the small intestine. Both sets of vessels form a perfect net-work, completely covering the interior surface of the intestinal canal; in the small intestine this net-work is closer to the chyle than anywhere else.

Absorption by Blood-Vessels.— The minute blood-vessels and capillaries in the mucous coat of the stomach and intestines (Fig. 47) absorb at *b* and *c*

completely digested aliment; this substance is so finely divided as to readily pass through the walls of the blood-vessels in the manner, roughly speaking, of water passing through (from *without* to the interior of) the walls of a hollow tube made of blot-

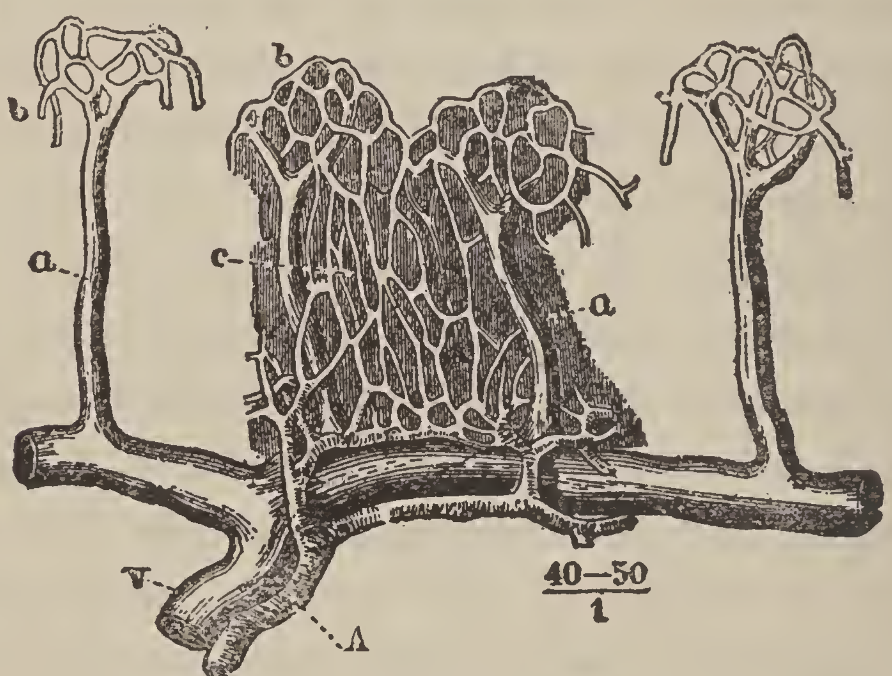

FIG. 47.

TRANSVERSE SECTION OF MUCOUS MEMBRANE OF COLON.

A, Artery. *V*, Vein. *a a*, Descending Veins. *b b*, Venous Net on Inner Surface. *c*, Capillaries in Mucous Membrane.

ting paper. The blood at *A* is arterial; on its passage through the capillaries, *b* and *c*, it absorbs chyle (together with waste materials), which renders it venous; through *a* it descends into vein *V*, to be ultimately conveyed to the lungs. The blood-vessels are not very particular in the choice of fluid particles; they absorb nearly all kinds except the fatty portions.

Water, and similar beverages, are believed to be absorbed by the blood-vessels of the stomach without passing into the duodenum.

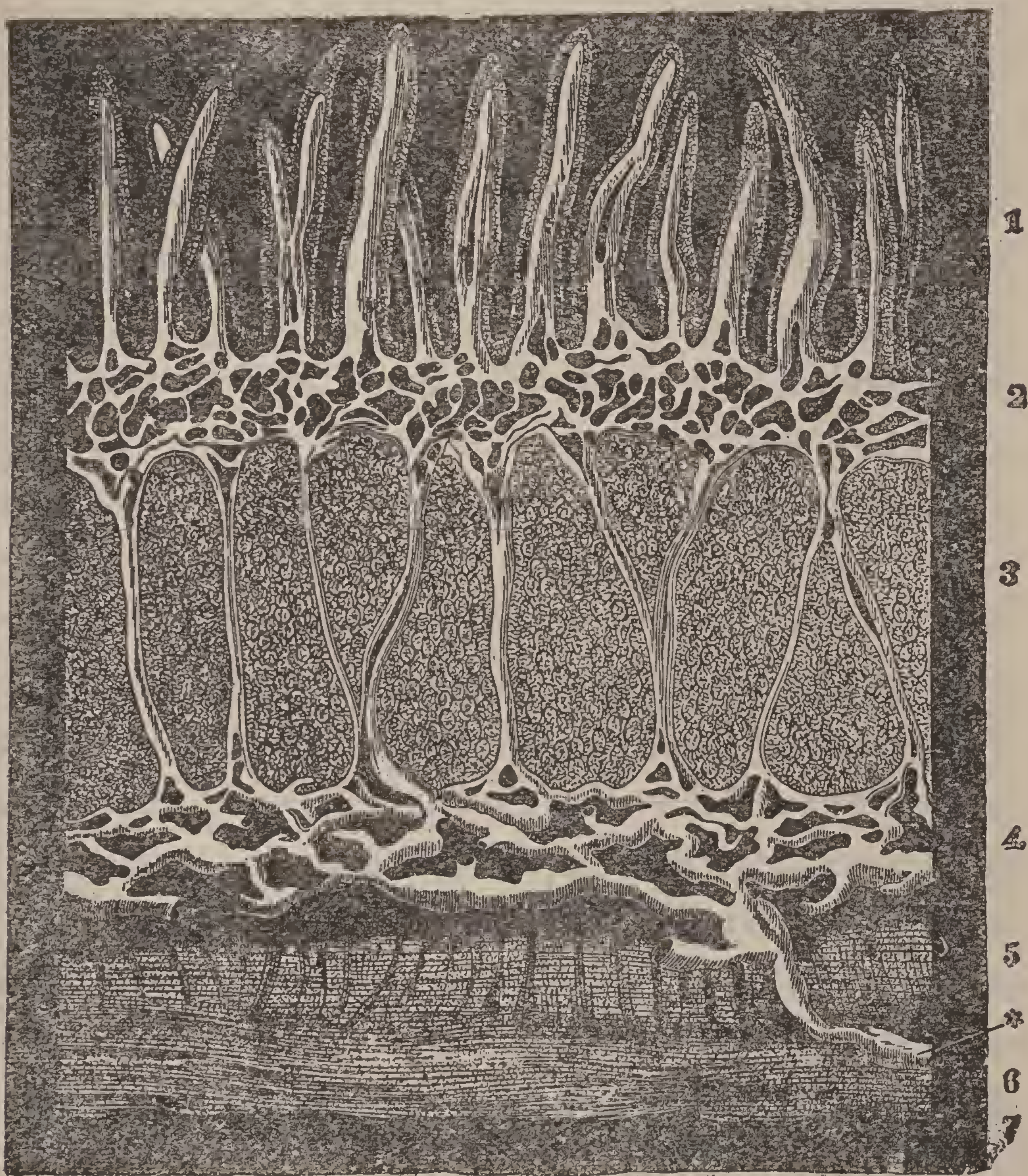

FIG 48.

TRANSVERSE SECTION OF THE DUODENUM OF A CALF.

1, Villi. 2, Interior Chyle-Vessels. 3, Glands. 4, Exterior Chyle-Vessels or Lacteals. 5, 6, Muscular Coat. * Valvular Chyle-Duct. 7, Skin.

Absorption by the Lacteals is carried on in the same manner. It is rendered most effective in the small intestine, because the interior wall of this intestine presents a larger surface to the chyle as it passes by. This greater extent of surface is owing to the fact that the mucous membrane which forms the interior surface, is folded into a great abundance of conical projections, called *villi* (Fig. 48), somewhat resembling the velvety projections of a Turkish towel. From the villi the absorbed materials pass through the interior chyle vessels, 2, and through glands, 3, to the exterior chyle vessels, or lacteals, 4. These vessels gradually increase in size, and on leaving the intestine obtain the valvular structure of veins. This prevents any absorbed chyle from flowing back to the villi. The way in which each *villus* imbibes the chyle is explained thus: The villi have minute muscles which cause them alternately to contract and expand; at every expansion each villus fills with chyle; at every contraction it squeezes its contents into the lacteal vessels beyond. The villi may be compared to the delicate root-fibres of plants, which are spread in the ground for the purpose of absorbing food for the plant; like the villi, these vegetable fibres are without openings, and yet, as is known from the fact that drooping leaves revive again after a shower on a hot day, they

are capable of absorption. The special function of the villi seems to be the absorption of the fatty portion of the chyle, although they absorb also other materials. The villi are found only in the small intestine.

The lacteals receive the chyle from the villi of the intestines (Fig. 48, *) mentioned above. The lymphatic glands (p. 132, Fig. 28) which are widely distributed in the body are found among the lacteals described on p. 132. The chyle on passing through them undergoes some change, and on leaving them it flows into the thoracic duct.

The thoracic duct (Fig. 45) is a tube of the width of a goose quill, nearly, which receives the chyle of the lacteal vessels and glands, and empties it into a vein on the left side of the chest, near the heart. A similar, smaller tube, likewise throws its contents into a vein on the right side of the chest, near the heart. Thus, the lacteal vessels are the carriers of the chyle on its way to the blood; they act like veins in this, that they contain valves to make their contents flow in one direction only; with one end they terminate in two ducts, which open into the large veins and finally into the heart; at the other end they terminate in microscopic

branches or lymph-capillaries, which are distributed throughout the tissues of the body. The villi form part of these lymph-capillaries. The lymphatic vessels of the intestinal canal pass by the name of *lacteals*, because their contents resemble milk in appearance; there is no difference between lacteals and lymphatics. It should be borne in mind that there are blood-vessels and capillaries within each villus as well as around the villi, which, as before mentioned, carry on absorption.

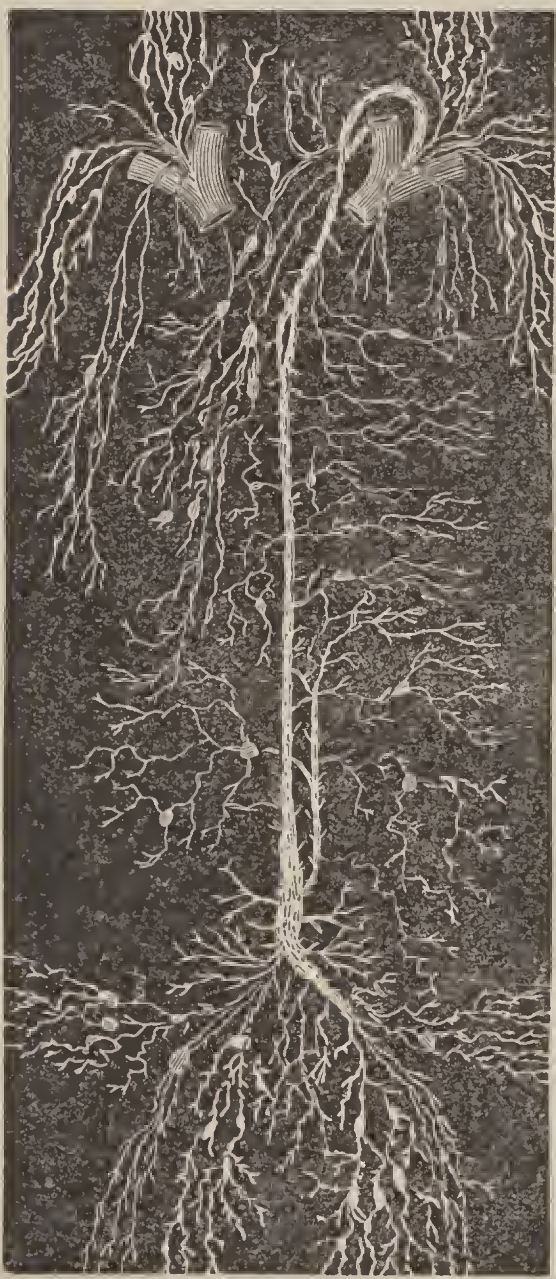

FIG. 49.
The Thoracic Duct.

From the preceding it is evident that man and the higher vertebrates have, in addition to the intricate system of arteries and veins, another of vessels, called the *lymphatic system*. (See p. 132). This contains a fluid called *lymph*, which

system is chyle altered by the lymphatic glands. As the blood-vessels have blood capillaries, so the lymphatic-vessels have lymph-capillaries near the skin; these widen into lymph-vessels toward the interior of the body.

5. FOOD.

The Subject of Food will be considered under four heads: (1) Necessity for Food; (2) Sources and Classes of Food; (3) Quantity and Quality of Food; (4) How and When Food Should be Taken.

(1) **The Necessity for Food** will be the first to be discussed: —

The Functions of the Human System cause a waste of tissues. This waste must be repaired or the individual will die. The human body is composed of combinations of carbon, hydrogen, oxygen, and nitrogen; hence it must be repaired by a supply of aliments containing these materials. When an organism is deprived of proper food it commences to feed upon itself.

Waste of Tissue arises from the incessant work which the body performs, consisting of mechanical motion, as when a person is walking, or a blacksmith

strikes a piece of iron on the anvil; or of vital functions, such as breathing. Not only is food required to supply the waste of tissue as well as to build up the organism at the beginning; but the temperature of the body must be maintained, for which the oxygen is so necessary. Hence, there may be three distinct offices of food: (1) To build up the being at the beginning; (2) To supply the waste after its growth is attained; (3) To maintain the normal temperature of the body; to appear hungry may be added as a secondary purpose of food.

*Hunger and Thirst.**— The man whom we sup-

* "We none of us object to a sharp-set appetite; that is by no means unpleasant, especially when there is food at hand; but if this is not the case, it soon becomes a craving passion — a strong impelling power. The cravings of hunger have done much for this world; 'look where we may, we see it as the motive power which sets the vast array of human machinery in action.' Hunger is also the incentive which directs our attention to the system's need for food, and if it be sharp enough the most loathsome substances are greedily devoured. By it has man, and civilized man, too, been driven to feed upon the putrid corpse of his comrade. Hunger is one of the great forces in action in the preservation of the life of the individual; and the fear of it is one of the strongest incentives to action. But the pangs of hunger are tolerable in comparison with the tortures of raging thirst. In fact, so terrible are the latter that they form one of the cruelest tortures which man can inflict on man; so

posed to take exercise in a glass-house would dwindle to nothing in due course of time unless he took food to repair his waste. The imperious sensations which remind us forcibly of the want of solid and liquid aliment are hunger and thirst. To satisfy the former, the body must be supplied with solid food; to satisfy the latter, with water in some shape or other.

The sensation of hunger seems to be seated in the stomach, but it is the call for food of the whole system; for when food enters the system by any other source, the sensation will disappear.

So it is with the sensation of thirst, which appears to be in the throat, but is really the cry of the entire body for water.

(2) **The Sources and Classes of Foods** deserve most careful attention, as the character of the food often determines the nature of the being. The following experiments show something of the nature and properties of the four chief elements of food:—

Experiment. — *Hydrogen* gas may be liberated from muriatic acid poured on a little zinc or on a nail

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cruel a torture, indeed, that it has rarely been used, except in cases of bitter personal animosity, by others than brutal Eastern tyrants, or bigots under the influence of religious fanaticism."—*Fothergill on the Maintenance of Health.*

in a test-tube. The gas is recognized by its burning with a pale, bluish flame. By connecting the mouth of the test-tube with a suitable tube, the gas may be conducted into a tumbler filled with and inverted over water.

Experiment. — *Oxygen* gas may be liberated from an ounce of pulverized potassium-chlorate mixed with a like quantity of manganese dioxide, by placing the mixture in a test-tube and applying heat. It may be recognized by its rekindling a glowing taper; like hydrogen, it is easily caught in an inverted tumbler.

Experiment. — *Nitrogen* gas may be obtained from common air by burning a short piece of candle, fastened on a fragment of board so as to float on water, and inverting a glass jar over the candle. The light will be extinguished, some water will rise into the jar, and nearly all the remaining gas will be nitrogen.

Carbon may be represented by a piece of coke or charcoal.

Hydrogen, *Oxygen*, *Nitrogen* — three gases — and *carbon* — a solid — are the principal elementary sub-

stances which, when combined with each other, form the materials composing the human body.

It is divided into *organic* and *inorganic* materials. (See p. 3.)

The following outline shows the classes of foods: —

- Food.
  - I. Organic ...
    - 1. Nitrogenous substances, or Albuminoids....
      - a. Albumen.
      - b. Fibrine and Gluten.
      - c. Caseine.
    - 2. Oleaginous Substances.........
      - Oils.
      - Fats.
    - 3. Saccharine Substances.........
      - Starch.
      - Sugar.
      - Gum.
  - II. Inorganic.
    - Water.
    - Salt (common).
    - Lime.
    - Iron.
    - Oxygen.
    - Soda.
    - Potash.
    - Magnesia, etc.

The last two classes, when pure, contain no nitrogen. Inorganic food comprises water, the most important article of food, and alkalies, such as salt and phosphates. No single class is generally considered sufficient; all of them are necessary to make food nutritive and convenient; a man feeding entirely upon bread and sugar may ultimately be starved as surely as one whose diet is composed solely of meat,

or of mineral water. Intuitively, we eat bread and meat, or bread and cheese, bacon and beans, stuffing and fowl. Persons who live largely on meat prefer it fat; those who live mostly on vegetables consume a great deal of milk, because milk contains the three classes of organic food, as well as inorganic materials.

Oxygen is an article of food, as it serves to maintain important vital functions. It is the only article of food which enters the system as a simple, or elementary body; all the others are compounds.

Organic Foods form the chief supply of aliment for the animal body, and the principal of these is the nitrogenous substances, which Liebig calls the *flesh-formers*, as he denominates the second and the third divisions as the *force-producers*, or *carbonaceous* foods.

Albumen is found in meat, grain, milk, and juices of plants, but the whites of eggs furnish it in the purest state. Albumen forms the greater part of brain tissue. It is colorless, tasteless, and without smell, and coagulates with heat, acids, and alcohol.

Fibrine is found in forming the basis of the muscles, the blood, lymph, and chyle. It is white, ordorless, and insoluble in cold water. It coagu-

lates at all temperatures. *Gluten* is vegetable fibrine.

Caseine is the curd-like ingredient in milk. It coagulates by the presence of acid, produced by fermentation, when the caseine may be separated from the watery part of the milk, termed *whey.*

The Oleaginous Substances form the second class of organic food substances. These belong with the sugar, etc., to Liebig's "force-producers." They are insoluble in water, but are suspended in the fluids of the body in finely divided state. Although both animals and plants supply oleaginous substances, the former furnish the greater amount for man's food.

The Starches, Sugars, and Gums constitute the third and last division of organic food substances. Starches and gums are of about the same nature as sugars, being composed of nearly the same proportion of elements and serving the same purpose in the animal economy. Most sugars are derived from plants, milk and honey furnishing the only supply from an animal origin. Sugar dissolves readily, has a sweet taste, with a tendency to ferment and crystallize.

Starch, as a vegetable principle, is abundant. It is formed of minute bodies of regular structure,

tasteless, without odor or crytallization, and dissolving only in boiling water. Its uses as a food-supply are universal.

Gum is similar to starch, but not so nutritious. It is in a better commercial form, and much used in the arts.

The Inorganic Foods are few in number, yet they are very important.

Water stands at the head of inorganic substances not only from its importance, but also from its abundance, as about three-fifths of the animal tissue is composed of water. It is found in all parts of the body, even in the composition of the teeth, which contain one-tenth water. Fifty per cent of the muscle tissue is water. Vegetables and fruit are largely composed of water. When we think of its composition, two parts oxygen and one hydrogen, by bulk, we realize how necessary to the life of the being it is.

Salt * is another chemical compound, composed of

* "Salt-cellars ever should stand at the head
Of dishes, wheresoe'er a table's spread.
Salt will all poisons expurgate with haste,

sodium and chlorine, which seems absolutely necessary to the healthfulness of animal bodies. It is present in nearly all plants and animal tissue, but is found and native, in solution in water in the mineral kingdom.

Without salt, animals cannot thrive. Their food is not properly digested, their skin becomes dry and rough, the hair falls out, and unless salt is secured, death will result. Salt as a medicine has many fine qualities known to every housewife.

Iron is necessary to the healthful state of the system, especially the muscles and the blood. In the blood, it forms one-tenth per cent of the substance. Iron seems to give color and vitality to the blood, being found in its red corpuscles.

Lime (*calcium* and *oxygen*) is the chief ingredient of the bones, where it is combined with phosphoric acid and carbon dioxide. Lime is found in

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And to insipid things impart a taste.
The richest food will be in great default
Of taste, without a pinch of sav'ry salt.
Yet of salt meats, the long-protracted use
Will both our sight and manhood, too, reduce;
On tables salt should stand both first and last,
Since, in its absence, there is no repast."

— *The Code of the School of Salernum.*

meat, milk, and the grains. It is necessary to the growing body, which would be subjected to serious consequences heretofore discussed on page 18.

Magnesia, found in the bones, brain, milk, etc.

Potash and Soda, found in the blood, bile, perspiration, milk, etc.

Phosphorus of the bones and **Sulphur** in the hair, muscles, bones, and nails, with some of the elements mentioned before, conclude the review of inorganic food substances, although a few others might be named.

(3) **The Quantity and Quality of Food** constitute the next topic of the subject, both of which exert a wide influence upon the welfare of man.

The Quantity and Quality of Food Depend Upon — (a) the health, (b) the climate, (c) the occupation, (d) the age, (e) the sex, and (f) the kind of food.

The Health of the body certainly determines to a great degree the supply of food required, for in sickness the organs are "out of tune," at which

time food is repelled. In good health, the stomach labors under too heavy a load, which admonishes one to guard the health. In some diseases, as dyspepsia for example, the stomach will take but little aliment, and that which is accepted produces excruciating pain. Not only must the quantity be modified in sickness, but also its quality and nature. Again, persons of spare form should make their diet largely of fats, starches, and sugars, while those whose plumpness offends the eyes should reject the foregoing regimen, and live more upon vegetables and less upon meats. Invalids, persons of weak constitution, and infants should not only eat sparingly, but their food should be of a light, nutritious nature. Gruels, broths, rice, vegetables, and light meats should make up the diet of such persons.

Little or no food will be required immediately after severe mental labor, continued singing and speaking, or laborious manual toil. Then the digestive system needs rest, not food.

Climate is an important factor in determining the *quantity* and *quality* of food. Every one knows the well-known facts, that the Esquimo subsists upon whale blubber and oil, taken in large quantities, but the inhabitant of the tropics lives almost entirely upon fruits, while the native of the temperate zone, who

is cosmopolitan in his tastes and requirements, levies for his food supplies upon the animal, mineral, and vegetable kingdoms of all climes.

One of the Arctic explorers speaks of an Esquimo who, after eating a hearty breakfast, came on board the ship, and ate twenty-four pounds of rice — a delicacy to him. It was no unusual thing for one of these odd people to eat a whole sheep at one sitting, or for two or three of them to eat the hind-quarters of an ox. In contrast to this is the light diet, in quantity and quality, customary among the people near the Equator.

Yet, the inhabitant of the temperate zone shows his superiority here, as well as in the field of intellect, and it has been determined that a mixed diet * is best

* "The mixed diet to which the inclination of man in temperate climates seems usually to lead him, when circumstances allow that inclination to develop itself freely appears to be fully conformable to the construction of his dental and digestive apparatus, as well as to his instinctive cravings. And whilst on the one hand it may be freely conceded to the advocates of 'vegetarianism,' that a well-selected vegetable diet is capable of producing, in the greatest number of individuals, the highest *physical* development of which they are capable, it may, on the other hand, be affirmed with equal certainty, that the substitution of a moderate proportion of animal flesh is in no way injurious; but, so far as our evidence at present extends, this seems rather to favor the highest *mental* development. And we can scarcely avoid the conclusion that the Creator, by conferring on man a remarkable range of

for man's highest development, physically, mentally, and morally; because no single article of diet contains all the elements required.

The Occupation (see table, page 254,) **Followed,** like the kind of exercise taken, affects the quantity and quality of the daily food supply. A person whose trade, business, or profession requires little or no exertion should regulate his diet accordingly, eating sparingly of meats and heavy foods; but, on the other hand, the laborer who from morning until evening, constantly uses shovel and pick, lifting heavy loads at the expense of muscular tissue, must have plenty of solid, wholesome, nutritious, *force-producing* food to supply this great waste. No meager diet will sustain him, which has been proven in the unfortunate cases of criminals put to hard labor without food in proper quantity and the right quality. Those occupations, requiring much time in the open air, superinduce a better condition of the digestive system, and make more food necessary.

Sex is to be considered under this head. Females, other conditions being equal, eat less than males.

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choice, intended to qualify him for subsisting on those articles of diet, whether animal or vegetable, which he finds most suitable to his tastes and wants."— *W. B. Carpenter on the Principles of Physiology.*

When the general nature and occupations of the two sexes are considered, this will be readily accounted for.

Age* serves notice of its varying demands upon the supply of food. In infancy the supply is simple and of a liquid nature, milk furnishing the ideal material at this period. It is interesting to know that milk also was the primitive food of the race. In youth, when the building-up process is so active, food must be abundant and taken often as the system demands, while in old age, as the "machine begins to run more slowly," the fuel is less and of not so heavy a nature. Hence, there is a reason for the

* Here is an interesting table showing the results of occupation upon longevity. It is worthy of thoughtful study: —

Employment.	Years.	Employment.	Years.
Judges	65	Masons	48
Farmers	64	Traders	46
Bank Officers	64	Tailors	44
Coopers	58	Jewelers	44
Public Officers	57	Manufacturers	43
Clergymen	56	Bakers	43
Shipwrights	55	Painters	43
Hatters	54	Shoemakers	43
Lawyers	54	Mechanics	43
Rope Makers	54	Editors	40
Blacksmiths	51	Musicians	39
Merchants	51	Printers	38
Calico Printers	51	Machinists	36
Physicians	51	Teachers	34
Butchers	50	Clerks	34
Carpenters	49	Operatives	32

strong appetite of the vigorous youth as compared with the reasonable, quiet demands of old age.

An infant requires absolutely less food than an adult, but relatively to their weights a much larger amount.

The Kinds of Food,* having been so fully discussed elsewhere, need but little attention here. As

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* DIGESTIBILITY OF FOODS.

ARTICLE OF FOOD.	Condition.	Hours Required.	ARTICLE OF FOOD.	Condition.	Hours Required.
Rice	Boiled	1 00	Soup beans	Boiled	3 00
Eggs, whipped	Raw	1 30	Soup, Chicken	"	3 00
Trout, salmon, fresh	Boiled	1 30	Apple dumpling	"	3 00
Apples, sweet and mellow	Raw	1 30	Fresh oysters	Roasted	3 15
Venison steak	Broiled	1 35	Pork steak	Broiled	3 15
Tapioca	Boiled	2 00	Fresh mutton	Roasted	3 15
Barley	"	2 00	Corn bread	Baked	3 15
Milk	"	2 00	Carrots	Boiled	3 15
Bullock's liver, fr'sh	Broiled	2 00	Fresh sausage	Broiled	3 20
Fresh eggs	Raw	2 00	Fresh flounder	Fried	3 30
Codfish, cured and dry	Boiled	2 00	Fresh catfish	"	3 30
Milk	Raw	2 15	Fresh oysters	Stewed	3 30
Wild turkey	Roasted	2 15	Butter	Melted	3 30
Domestic turkey	"	2 30	Old strong cheese	Raw	3 30
Goose	"	2 30	Mutton soup	Boiled	3 30
Sucking pig	"	2 30	Oyster soup	"	3 30
Fresh lamb	Broiled	2 30	Fresh wheat bread	Baked	3 30
Hash, meat and vegetables	Warmed	2 30	Flat turnips	Boiled	3 30
Beans and pod	Boiled	2 30	Irish potatoes	"	3 30
Parsnips	"	2 30	Fresh eggs	Hard boiled	3 30
Irish potatoes	Roasted	2 30	" "	Fried	3 30
Chicken	Fricassee	2 45	Green corn and beans	Boiled	3 45
Custard	Baked	2 45	Beets	"	3 45
Salt Beef	Boiled	2 45	Fresh lean beef	Fried	4 00
Sour and hard apples	Raw	2 50	Fresh veal	Broiled	4 00
Fresh oysters	"	2 55	Domestic fowls	Roasted	4 00
Fresh eggs	Soft boiled	3 00	Ducks	"	4 00
Beef, fresh, lean and rare	Roasted	3 00	Beef soup, vegetables and bread	Boiled	4 00
Beef steak	Broiled	3 00	Pork, recently salted	"	4 30
Pork, recently salted	Stewed	3 00	Fresh veal	Fried	4 30
Fresh mutton	Boiled	3 00	Cabbage with vinegar	Boiled	4 30
			Pork, fat and lean	Roasted	5 30

to what a person should eat or should not eat is a matter he should settle for himself. Experience shows that those who think little and say less about what they ought to eat, but who eat at the proper times and in the proper quantities, may take almost anything with impunity. Quantity kills oftener than kind. The person of reasonably good digestion may eat any kind of food he chooses, provided it is thoroughly masticated. Yet that which is most easily digested is not always best, as it may pass through the system too rapidly. Starch, arrowroot, sago and tapioca contain no nitrogen, and would not long sustain the vital functions. The careful perusal of the preceding pages and the study of the table below will suggest what ought to be one's diet.

Below is appended an interesting and useful table of an ideal daily diet, by Augustus D. Waller, which he divides into *foundation* and *accessories*.

Foundation	1 pound bread, ½ pound meat, ¼ pound fat.
Accessories	1 pound potatoes, ½ pint milk, ¼ pound eggs, ⅛ pound cheese.

(4) **How and When Food Should be Taken** is the fourth and not the least important of these topics.

The Condition of Food when taken into the system is an all-important matter. The experience of civilized man leads to the conclusion that food for his use should be cooked. Cooking, or rather proper cooking, is a problem that receives too little attention in these days. What mischief may result from an improperly cooked piece of meat or what danger may lie in a pudding, tempting to the taste, yet fatal to the stomach,* are questions of more than ordinary interest, and deserve more than a passing notice. Years are spent in learning to perform indifferently upon a musical instrument, while the time spent to supply the proper material for the most perfect of all instruments — the human body — is meager and beggarly. Let the women of the land work a social revolution upon the subject of cooking.

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* The stomach is the mainspring of our system; if it be not sufficiently wound up to warm and support the circulation, the whole business of life, in proportion, is ineffectually performed; we can neither think with precision, walk with vigor, sit with comfort, nor sleep with tranquility. There would be no difficulty in proving that it influences, much more than people imagine, all our actions."

"The fact is, that by skillful manipulation the plainest fare may be transformed into dishes fit for kings; while by ignorance and inattention, the best viands may be rendered unfit for human food. Dyspepsia is a fearful foe to the human race."—*The Housewife's Library.*

The Time at Which Food Should be Taken depends upon many things.

Should the body be *tired from vigorous exercise or heavy work*, or in a *heated condition*, food should not be eaten until the individual is partially rested and

While eating do not drink too much, as the saliva will not flow so freely under these conditions, and then the stomach is more apt to be overloaded. Yet, fluids may be used at meals, if used in the proper manner and quantity.

An old saying: *Never go to bed on a full stomach*, may be supplemented by *never going to bed on an empty stomach.**

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* "It is a common impression that to take food immediately before going to bed and to sleep is unwise. Such a suggestion is answered by a reminder that the instinct of animals prompts them to sleep as soon as they have eaten; and in summer an after-dinner nap, especially when that meal is taken at mid-day, is a luxury indulged in by many. If the ordinary hour of the meal is 6 or 7 o'clock, and of the first morning meal 7 or 8 o'clock, an interval of twelve hours, or more, elapses without food, and, for persons whose nutrition is at fault, this is altogether too long a period of fasting. That such an interval without food is permitted, explains many a restless night, and much of the head and backache, and the languid, half-rested condition on rising, which is accompanied by no appetite for breakfast. This meal itself often dissipates these sensations. It is, therefore, desirable, if not essential, when increased nutriment is needed, that the last thing before going to bed should be the taking of food. Sleeplessness is sometimes

6. HYGIENE AND DISORDERS.

HYGIENE OF THE DIGESTIVE SYSTEM.

Under the heading, "How and when Food should be Taken," much has been said that would apply to the present topic; however, some additional remarks in a general way will not be out of place at this point.

It might be laid down as a general law, *that the organs do one thing at a time;* hence, when one set of organs is laboring at one thing, another duty can not be done and be well done. In work, mental or physical, the muscular and mental powers of the body are employed, and the stomach should have rest. During, and for a time after meals, the stomach is at work, at which time the physical and mental powers should rest. The blood, like a trusty servant, hastens to the place where its master needs it. During digestion it waits upon that system; while physical employment or exercise is going on

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caused by starvation, and a tumbler of milk, if drunk in the middle of the night, will often put people to sleep when hypnotics would fail of their purpose. Food, on rising, is equally important and expedient. It supplies strength for prolonged bathing and dressing, laborious and wearisome tasks for the underfed, and is a better morning 'pick-me-up' than any other of the too often resorted to 'tonics.'"—*R. M. Hodges.*

it is with the muscles, and finally when the brain labors, there this trusty servant will be found, at all of which times it leaves the other portions of the system not well attended.

How much food must be taken is a question that comes to each one. As a precept that will be of great service follow this: —

Stop eating before your appetite is fully satisfied. It is difficult to do this, but it can be done if the *will* rules the *stomach*, but if the *stomach* rules the *will*, there's danger.

Food should not be taken immediately *following close mental application*, *long-continued speaking or singing*, as the digestive system needs a little recuperation. This accounts for the listless way in which teachers or clerks will sit down to their meals when a cheerful, lively spirit ought to prevail.

Sad or unexpected news will unfit the individual for taking food. Under this head, attention is called to the reprehensible habit of discussing unpleasant, disagreeable, or harrowing subjects at the table. On the contrary, light, pleasant, humorous conversation should prevail during the meal time.

Meals should be eaten regularly, as the bodily organism will form this habit, and it is a good one.

Should the time of meals be postponed, overeating may be the result. Again, after the natural desires of food — hunger — has subsided one may not care much for nourishment, hence, careless habits and evil effects will follow.

Use condiments very sparingly, as the cessation of appetite is notice that the stomach needs less food. There is no appetizer better than the thorough mastication of the food.

DISORDERS OF THE DIGESTIVE SYSTEM.

Among the most common disorders of the digestive apparatus may be mentioned the following: *Dyspepsia*, *Acidity of the Stomach*, *Colic*, *Constipation*, *Diarrhea*, *Bilousness* and *Peritonitis*,.

Dyspepsia is literally poor digestion, or as it is commonly termed, *indigestion*, which is a lack of tone and strength in the digestive apparatus. It may be inherited. Alcoholic drinks, drinking ice water at meals, imperfect mastication, overeating, and irregular meals are fruitful causes of the disorder.

Treatment.— First remove any or all of the above causes. Eat sparingly, and of fresh meats, oysters, eggs, fresh vegetables, rice, tapioca, oatmeal, fruits, using hot-water drinks with some mild tonic, as calumba. By proper care, dyspepsia, in its incipient

stages, may be permanently cured. Lime water and milk is an excellent remedy.

Acidity of the Stomach is heart-burn, water brash, belching of gas, etc., accompanied by a sallow complexion, painful digestion, and mental despondency, and caused by a derangement of the acids and alkalies of the alimentary canal.

Treatment.—In general, too much alkali may be counteracted by daily taking a mineral acid, while the superabundance of acids may be overcome by doses of alkali. Certain waters, recommended by physicians, may be secured that will gradually cure this disorder.

Colic has several forms, the most common being the one affecting the stomach, and caused by exposure, or eating indigestible and unwholesome food, followed by sudden and severe pains, which come and go at intervals.

Treatment.—When due to something that has been eaten, administer an emetic, or a mild laxative. Unless one of the special forms, colic is unpleasant but not serious.

Important Facts. — No system of the human body admits of more varying effects, from varying conditions and environment, than the digestive, whose field seems to be full of paradoxes. In tastes, appetites, powers of digestion, physiology, habit, — in fact, in all powers, peculiarities, and affinities, men differ as widely as they do in longevity, stature, and weight; hence it is difficult to deduce laws and principles from the results obtained in the study of this department of human physiology, yet a few general and specific facts will be interesting, if not useful.

Certain articles of diet are prescribed, yet it is said that Pythagoras, the early Grecian philosopher, lived to a ripe old age upon bread and honey, while John the Baptist subsisted upon "locusts and wild honey." A reputable medical journal tells of a man in Central America, who lived to be 164 years old, who ate but one meal a day and that cold, who drank nothing but cold water, and whose skin was like parchment. The wonderful experiments of Dr. Beaumont upon Alexis St. Martin shows how "God moves in a mysterious way his wonders to perform," — when, by a serious accident to St. Martin, the mysteries of

digestion have been recorded. Dr. Tanner, in our times, lived forty days without food.

Man requires daily about six pounds of food, of which the mineral kingdom supplies three and a half pounds; the vegetable kingdom, one and one-half pounds, and the animal kingdom, one pound, all of which amount is about one twenty-fifth of the body.

The body renews itself according to good authorities about once in seven years. Of course this process of renewal and decay is going on at every moment of time.

The great length of the alimentary canal is necesary that every particle of nutriment may be extracted by the numberless absorbents along the way.

REVIEW QUESTIONS.

1. Give Dr. Hunter's views of the stomach.

2. In what respect is the human body like a machine? What makes the body do its work? What the steam-engine?

3. How does working depend upon food? How does thought?

4. How does the food of plants differ from that of animals?

5. From what source is the chief supply of food for animals and plants?

6. Name the changes, or processes that food undergoes in the body.

7. What is the chief channel by which food enters the body? Name an exception.

8. State the organs of digestion. What organ is classed here, although not strictly belonging to this classification?

9. Describe the mouth. To what may it be compared?

10. Tell what you know about the teeth, their structure, kinds, number, and uses. How do the teeth of carnivorous animals differ from those of herbivorous? Describe the pharynx. How many openings has it?

11. Name the salivary glands. On which jaw are they? Which are affected in mumps? What is the *frænum linguæ*? Where are the mucous glandules? To what may the salivary glands be likened?

12. Locate and describe the œsophagus.

13. Why is the stomach so important? What other organ is near it in size? Locate the stomach. Name and locate its two openings. Give and describe its three coats. What juice does it contain? Give its size, capacity, appearance, and rugæ.

14. Give the chief and subdivisions of the intestines. Give the

length of each main division. In what respect are the intestines like the stomach? What is the alimentary canal? How long is it? Describe each part of the small intestine. Of the large.

15. What is the meaning of the name of each part of the small and the large intestine?

16. What is the omentum? Give another name for it? How many coats has it? Its use?

17. Describe the liver, giving its size, dimensions, location, composition, and uses.

18. Where is the gall-cyst, or gall-bladder? Describe it. Give its uses.

19. What is the description of the pancreas? In what respect is it like the liver?

20. What is the use of the spleen? Describe this organ. How is it unlike the liver and pancreas?

21. Describe fully the lacteals. What are the *villi*? The *mesentery*? Lymphatic glands?

22. Tell what you know of the *thoracic duct*, as to location, size, structure, and uses. Into what vein does it empty its contents? How many coats have the lacteals and thoracic duct?

23. Give a full description of the kidneys. With what organ do they connect? What is the peritoneum?

24. Describe the process of mastication. Food undergoes what two changes in digestion? What is the use of the tongue in mastication? Which jaw is the more important?

25. Explain *insalivation*. How is starch in plants changed to sugar? Why are mastication and insalivation so important? Sum up the uses of saliva.

26. Follow out carefully the process of deglutition. What part does the tongue play here? What keeps the food from entering the windpipe?

27. Tell what you know about the œsophagus regarding digestion. Give the manner of getting food down the gullet.

28. Describe the process of stomach digestion. What is the gastric juice? Which coat gives the physical action? What is the peristaltic motion? What is chyme? What muscles act in vomiting? Give the power of gastric juice. How does alcohol hurt the stomach? Give the different properties of gastric juice and their effects? What is albuminose? How many pounds of gastric juice are daily secreted?

29. Give the condition of chyme, as it leaves the stomach. Name the chief functions of the stomach.

30. State the conditions favorable to stomach digestion.

31. Describe the digestion in the intestines. What are the properties and uses of the bile, of the pancreatic juice? What is the effect of bile, if not allowed to enter the duodenum? How does the nervous system affect the flow of digestive juices? What is chyle?

32. Describe the intestinal juice. Give its uses. Give the amount of these five juices daily secreted.

33. Compare chyme and chyle. Why is food necessary? What vessels take the chyle from the intestines and transfer it to the thoracic duct?

34. Describe the process of absorption by the blood-vessels. Absorption by the lacteals. What part do the *villi* play? What membrane holds the lacteals and lymphatic glands in place?

35. Describe the process of digestion in the thoracic duct? What two systems of circulation has man?

36. What causes waste of tissue? Give the example of the man in a glass-house. What are the relations of building-up and tearing-down processes in the different stages of life? Give the three uses of foods.

37. Tell what you know of hunger and thirst. Define each.

38. Name some of the elements that largely enter into our food supply. Show how each may be obtained. Give the relation of animal, mineral, and vegetable kingdoms.

BLACKBOARD OUTLINE.

VII. THE DIGESTIVE SYSTEM.

1. **Introduction.**
   - Human Body.
   - Food of Plants.
   - Changes of Food by
     - Digestion.
     - Absorption and Assimilation.
     - Excretion.

2. **The Organs of Digestion** (*named below*).

3. **Their Structure.**
   - *a.* The Mouth.
     - Organs of Mastication.
     - Organs of Taste.
   - *b.* The Teeth.
     - Number.
     - Parts.
     - Structure.
   - *c.* The Salivary Glands.
     - 2 Parotids.
     - 2 Submaxillaries.
     - 2 Linguals.
     - Ducts.
   - *d.* The Pharynx — Its Openings.
   - *e.* The Oesophagus — Structure.
   - *f.* The Stomach.
     - Location.
     - Structure.....
       - Coats.
       - Openings.
       - Dimensions.
     - Gastric Juice.
     - Glands.
   - *g.* The Intestines.
     - Small,
       - Duodenum.
       - Jejunum.
       - Ileum.
     - Large.
       - Cæcum.
       - Colon.
       - Rectum.
   - *h.* The Liver.
     - Duct.
     - Cells.
     - Juice.
   - *i.*
     - Gall-Cyst.
     - Pancreas.
     - Spleen.
   - *j.*
     - The Lacteals.
     - The Thoracic Duct.
   - *k.*
     - The Kidneys.
     - The Omentum.

4. **The Process of Digestion — Through the Above Organs.**

5. **Food.**
   1. Necessity for.
   2. Sources and Classes of.
   3. Quantity and Quality of.
   4. How and When Food Should be Taken.

6. **Hygiene and Disorders.**
   - *a.* Hygiene.
     - Rules of.
     - Necessity of.
   - *b.* Disorders.
     - Dyspepsia.
     - Acidity of the Stomach.
     - Colic.

VIII.

THE NERVOUS SYSTEM.

Then mark the cloven sphere that holds
All thought in its mysterious folds;
That feels sensation's faintest thrill,
And flashes forth the sovereign will;
Think on the stormy world that dwells
Locked in its dim and clustering cells!
The lightning gleams of power it sheds
Along its hollow, glassy threads!

— *Holmes.*

THE CEREBRO-SPINAL SYSTEM.

VIII. The Nervous System.

1. INTRODUCTION.

We have become acquainted with the various bones and tissues which compose the *structure* of the body; with some of the muscles which *move* the body; with the *alimentary canal* and its *secretions*, which convert food into nutriment; with the *organs of circulation* — the heart, the blood-vessels, the lymphatics — distributing nutriment all over the body; and with several *organs* serving to withdraw waste material from the body, such as the skin and the lungs. We must now gain an insight into a powerful organ, called the *nervous system*. It is distinct from all other systems in the body. The following are its general functions:—

(1) It connects the different portions and organs of the body into an organic unit, or whole. Thus a violent shock to the nervous system, such as great anger or fear, may cause increased action of the heart, an accelerated pulse, and immediate loss of consciousness. Here, then, the nervous system acts upon the blood-vessels; these act upon the muscles, and this combined action causes not only

single portions of the body to succumb, but the entire body as a unit.

(2) It animates, or governs, all movements of the muscles, whether these be voluntary or not. Thus, when a person endeavors to resist a yawn, to repress laughter or tears, a distinct exertion of muscles is requisite for his effort. This is voluntary motion prompted by an act of his will; whereas, the churning motion of the stomach is an example of an involuntary movement governed by the proper nerves.

(3) It regulates the temperature, nutrition, and secretion of the body. Thus, sudden fear often produces a chilling effect in lowering the temperature of the skin; weakness of the nervous system nearly always impairs the digestive process; intense anguish frequently causes increased perspiration.

(4) It controls the processes of nutrition. This may be proved by the fact that the injury of a nerve leading to a tissue is frequently followed by the waste or destruction of the tissue.

(5) It receives impressions, which are communicated by its terminal branches. Lateral pressure against the eye-ball causes a luminous impression or image; this is owing to the pressure exerted upon the delicate terminal branches of the optic nerve.

(6) It conveys impressions to different portions of the body. In leaping, if a person alights upon the heel he will feel the shocking pains in the back part of the head; the impression made at the foot is, by the nerves, conveyed to the head.

(7) It can generate influences which no other organ or system can produce, such as sight, smell, taste, etc., etc. By virtue of this function, it puts the body in direct communication with the outer world. This is evident, for a living being without the senses of sight, smell, taste, hearing, touch, and sensibility, if existing at all,

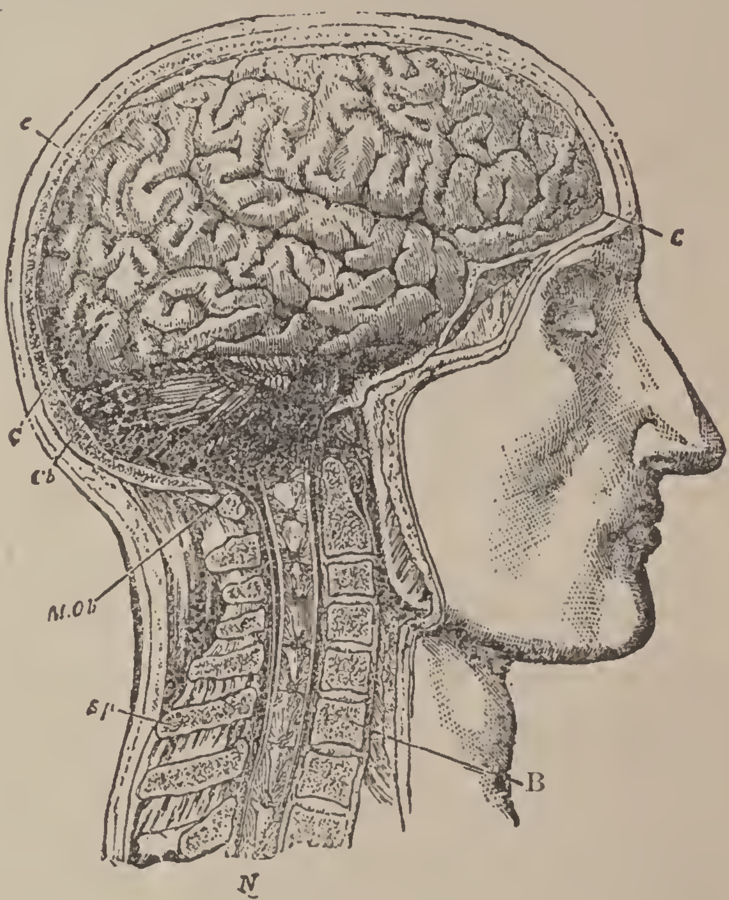

FIG. 50.

BRAIN AND SPINAL CORD.

A side view of the brain and upper part of the spinal cord in place—the parts which cover the cerebro-spinal centers being removed. *CC*, the convoluted surface of the right cerebral hemisphere; *Cb.*, the cerebellum; *M. Ob.*, the medulla oblongata; *B.*, the bodies of the cervical vertebræ; *Sp.*, their spines; *N.*, the spinal cord with the spinal nerves.

would be utterly unconscious of the world around him.*

In Structure, the nervous system, although a continuous substance, is conveniently subdivided into two systems: (1) the *cerebro-spinal system*, and (2) the *sympathetic system*. The former comprises the *cerebro-spinal axis* — that is, the *brain* and the *spinal* cord — together with the *cerebral* and *spinal nerves* which emanate from this axis. The sympathetic system contains the chain of *sympathetic ganglia* and the *nerves* which they give off.

The intimate structure of this system differs from any tissue which we have before examined. It is composed of a soft, pulpy substance, which early in life is almost fluid, but which gradually hardens with the growth of the body. When examined under the microscope, it is found to be composed of two distinct elements: (1) the white substance, composing the larger proportion of the nervous organs of the body, which is formed of delicate cylindrical filaments,

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* The organs of circulation, respiration, and digestion of which we have already spoken are called the *vegetative functions*, because they belong also to the vegetable kingdom. The nervous system with its organs of sense constitute what are known as the *animal functions*, because they are found only in the animal kingdom.

about $\frac{1}{6000}$ of an inch in diameter, termed the nerve fibres; and (2) the gray substance, composed of

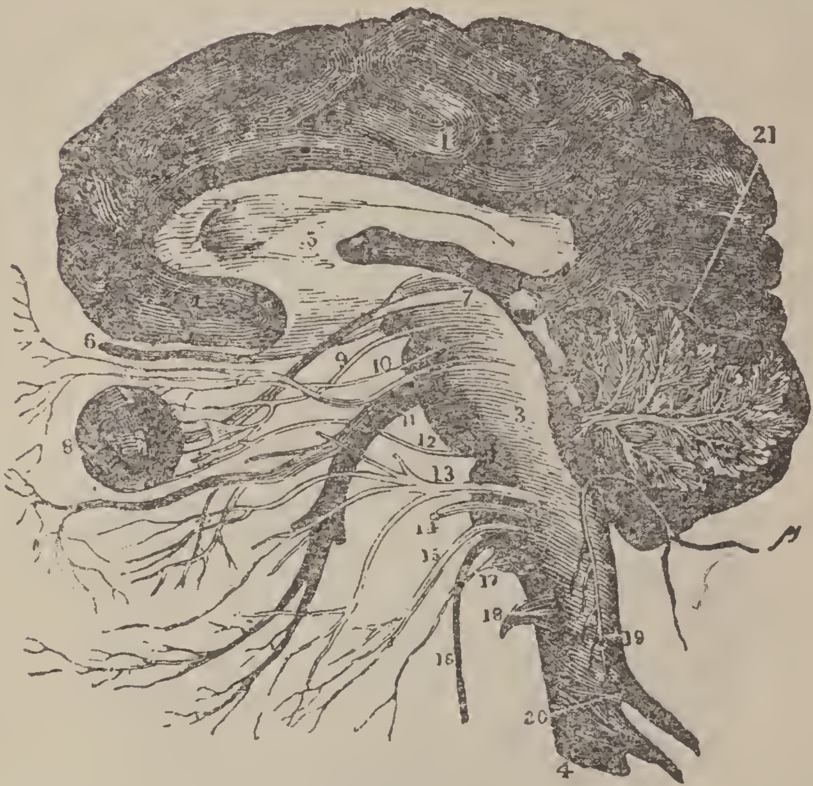

FIG. 51.

A VERTICAL SECTION OF THE CEREBRUM, CEREBELLUM AND MEDULLA OBLONGATA.

Showing the relation of the cranial nerves at their origin. 1. The cerebrum. 2. The cerebellum with its arbor vitæ represented. 3. The medulla oblongata. 4. The spinal cord. 5. The corpus callosum. 6. The first pair of nerves. 7. The second pair. 8. The eye. 9. The third pair of nerves. 10. The fourth pair. 11. The fifth pair. 12. The sixth pair. 13. The seventh pair. 14. The eighth pair. 15. The ninth pair. 16. The tenth pair. 17. The eleventh pair. 18. The twelfth pair. 20. Spinal nerves. 21. The tentorium.

grayish-red, or ashen-colored cells, of various sizes, generally possessing one or more off-shoots, which are continuous with the nerve-fibres just mentioned.

The gray, cellular substance constitutes the larger portion of the brain and is very liberal, amounting

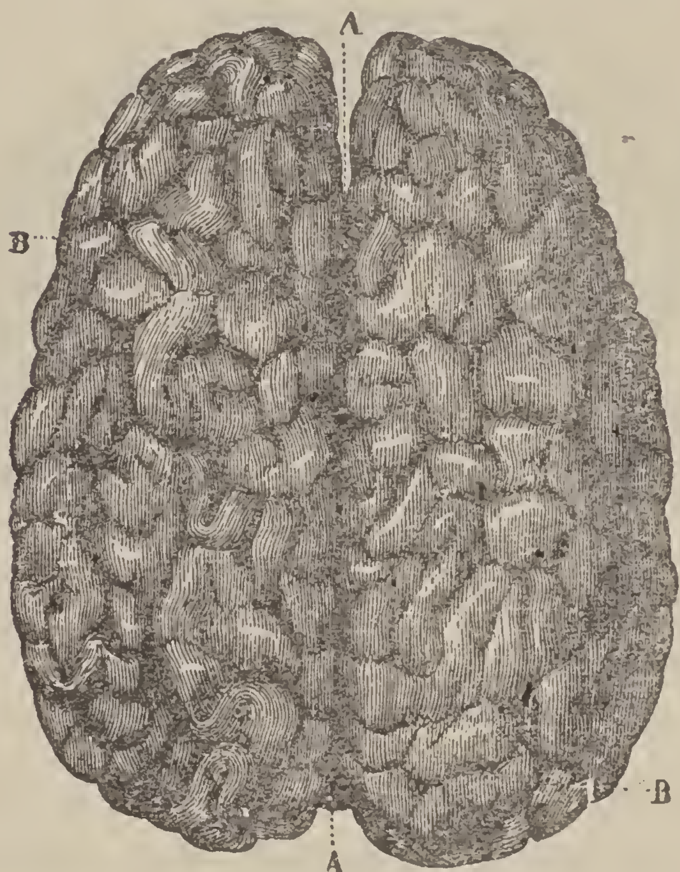

FIG. 52.

UPPER SURFACE OF THE CEREBRUM.

A, Longitudinal Fissure.
B, The Hemispheres.

to one-fifth of all that the entire body possesses. The brain of man is heavier than that of any other animal, except the elephant and whale.*

* Cuvier's brain weighed 64½ ounces; Webster's, 53½ ounces; James Fisk's, 58 ounces; Ruloff's, 59 ounces; an idiot's, 19 ounces.—*Flint.*

2. THE CEREBRO-SPINAL SYSTEM.

The Brain, (Fig. 50) the seat of the mind, is a very soft substance, forming in man the enlarged upper terminus of the spinal cord. It is encased in the cavity of the cranium, which it fills, and from which it is difficult to be extracted

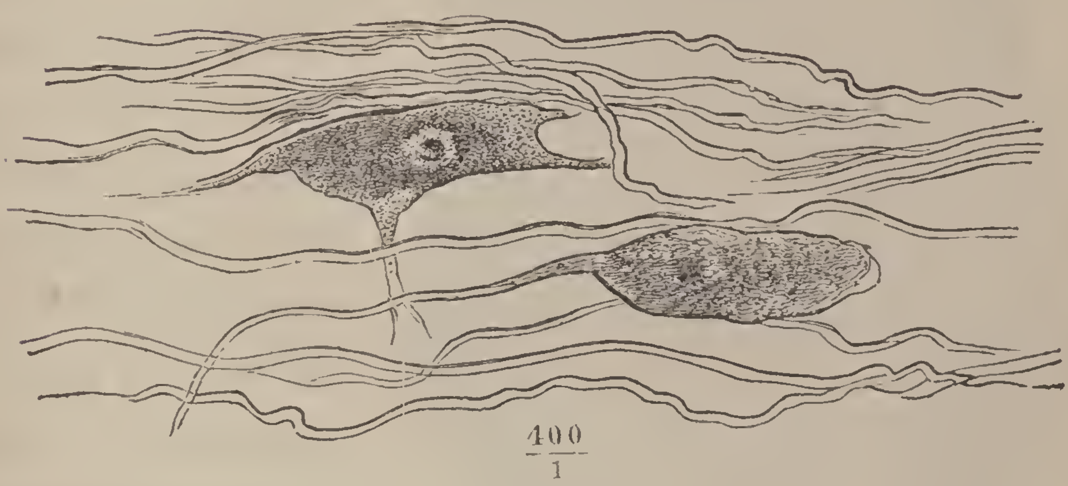

FIG. 53.

Two Nerve Cells and Nerve Fibres from the Brain. Magnified 400 times.

entire. The brain substance of man generally varies in weight from 40 to 60 ounces, and it is universally admitted that, as a rule, the quantity of brain substance corresponds to the intellectual powers of the individual, although it is believed that the quality of this substance also plays an important part. The

brain is surrounded by three membranes. The external membrane (*Dura Mater*) is thick and firm; the middle (*Arachnoid*) is thin, and looks somewhat like a spider's web, as the name means; the inner (*Pia Mater*) consists of a network of blood-vessels.

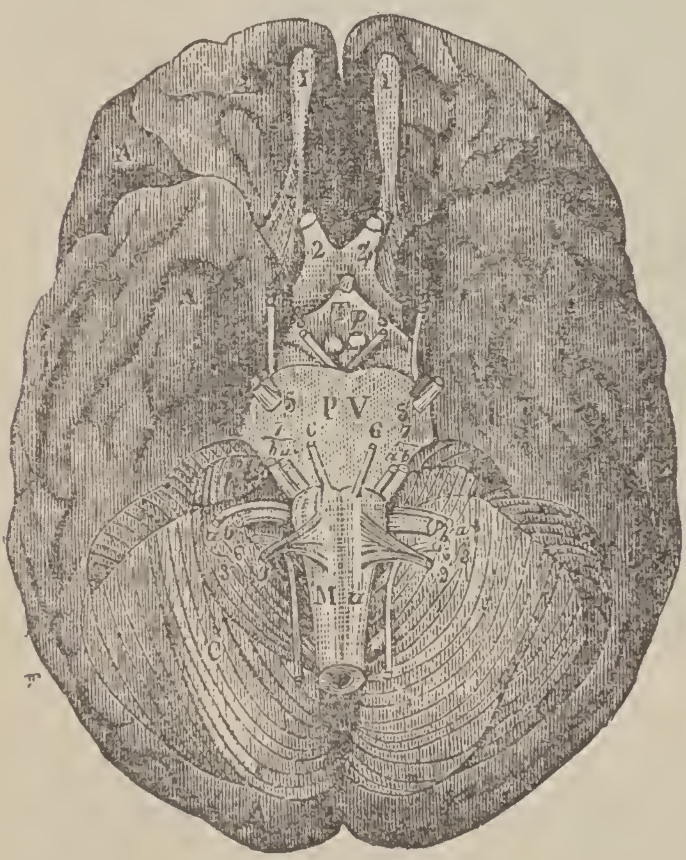

FIG. 54.

LOWER SURFACE OF THE BRAIN.

The numbers refer to the pairs of nerves.

These membranes are prolonged so as to form a sheath to the spinal cord. The brain consists of cells and fibres (Fig. 53), which are rendered visible only by a good microscope. The brain is divided into the large brain or *cerebrum*, the small brain or *cerebellum*—about one-eighth as large as the former—and the enlarged spinal cord, or *medulla oblongata*. (Fig. 51.)

The Cerebrum in man and apes entirely cov-

ers the cerebellum. It entirely fills the front and upper part of the skull and is about seven-eighths of the entire weight of the brain. The cerebrum and cerebellum consist each of two hemispheres (Figs. 52 and 54), one on the right, the other on the left side. The surface of the cerebrum is gray in color, consisting chiefly of nerve-cells, arranged so as to form a layer of gray matter one-fifth of an inch in thickness, and is abundantly supplied with blood-vessels. The interior of the brain, however, is composed almost wholly of white substance, or nerve-fibres. It is covered with a great many foldings and windings, or convolutions, irregular in form and direction (Fig. 51); these are separated from each other by deep furrows. Into these furrows the gray matter of the surface is extended, and, in this manner, its quantity is vastly increased. The extent of the entire surface of the brain, with the convolutions unfolded, is computed to be equal to four square feet; and yet it is easily inclosed within the narrow limits of

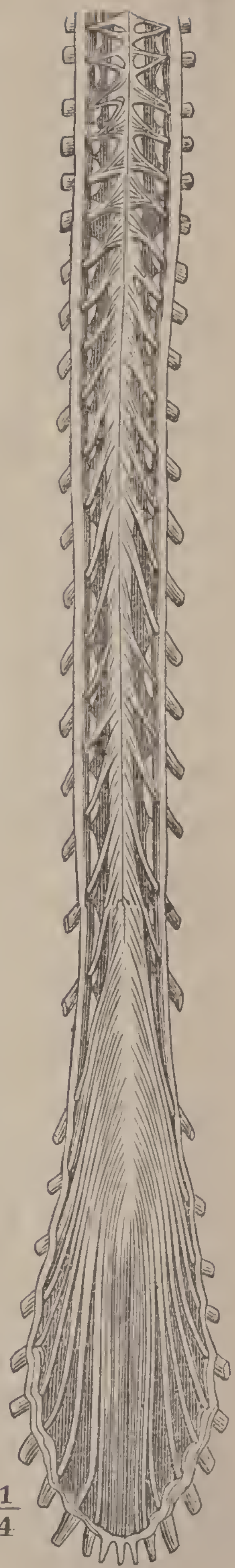

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FIG. 55.
The Spinal Cord, front view, with the projecting nerves cut off.

the skull. The gray matter is the true source of nervous power.

The Cerebellum, the "little brain," is placed beneath the posterior part of the cerebrum, and, like the latter, is divided into hemispheres. Like it, also, the surface of the cerebellum is composed of gray matter, and its interior is chiefly white matter. It has, however, no convolutions, but is subdivided by many parallel ridges, which, sending down gray matter deeply into the white, central portion, give the latter a somewhat branched appearance. This peculiar appearance has been called the *arbor vitæ*, or the "tree of life," from the fact that when a section of the organ is made it bears some resemblance to the trunk and branches of a tree (Fig. 51). In size, this cerebellum, or "little brain," is less than one-eighth of the cerebrum. This part of the brain seems to control the voluntary muscles, particularly those of locomotion. Yet its exact functions are not positively known.

The Medulla Oblongata (Fig. 51) preserves the connection between the spinal cord and the brain. Its columns are continuous with those of the cord, but contain a larger quantity of gray substance.

Motory impressions are carried through its anterior, and sensitive impression its posterior columns. No other part of the body is so immediately important to the maintenance of life as the Medulla Oblongata.

The Spinal Cord (Fig. 55) is the downward continuation of the medulla oblongata. It is a soft substance contained in a bony cavity, formed by the vertebral column or back-bone. It is unlike the brain, in that the white matter is on the outside and the gray within (Fig. 56). It extends nearly to the sacrum; it is furrowed like the brain into two lateral symmetric parts. Between these two parts — that is, in the center of the cord and through its entire length — runs a fine canal, which originates in a point betweeen the cerebellum and the medulla oblongata.

The Cerebro-spinal Nerves originate in both the brain and the spinal cord, whence they ramify and spread all over the body (Fig. 51). They have the form of fibres and cells. A nervous fibre is often made up of minute tubes; each tube contains a peculiar transparent, semi-solid substance which contains a thick fluid. The nervous fibres terminate in the organs to which they lead, and there form terminal branches. The nervous tubes vary in size from

one-thousandth of an inch to much smaller sizes; in the spinal cord they are much smaller; in the brain they are smallest.

The Cranial Nerves are arranged in twelve pairs originating in the base of the brain and the medulla oblongata (Fig. 51).

(1) *The Olfactory* extend to the walls of the nostrils, and are nerves *of smell.*

(2) *The Optic*, is the nerve of sight in the eye-ball.

(3), (4), (6), *The Motores Oculi* (movers of the eyes) used for motion of the eye.

(5) *The Trifacial*, the nerve of three branches, supplies the face, mouth, and tongue; first branch to the upper part of the face; second to the upper jaw and teeth; third to lower jaw and mouth forming nerve of taste. Because of derangement of these branches we have toothache and neuralgia.

(7) *The facial*, for expression of the face.

(8) *The Auditory* goes to the ear and gives the sense of hearing.

(9) *The Glos-so-pha-ryn'-ge-al* to the pharynx.

(10) *The Pneumeogastric* to the lungs, heart, stomach, and liver.

(11) *The Accessory* to the larynx.

(12) *The Hypoglossal* to the tongue, giving it motion.

The Spinal Nerves, thirty-one pairs in number, spring from each side of the cord by two roots, an anterior and a posterior root, which have the same

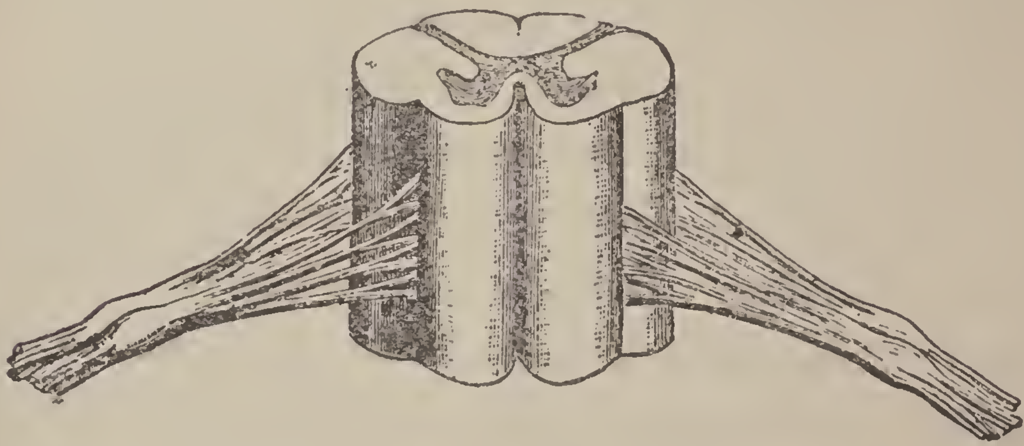

FIG. 56.

SECTION OF SPINAL CORD, WITH ROOTS OF SPINAL NERVES. FRONT VIEW.

functions as the columns bearing similar names (Fig. 56). The posterior root is distinguished by possessing a ganglion of gray matter, and by a somewhat larger size. The successive points of departure, or the off-shooting of these nerves, occur at short and nearly regular intervals along the course of the spinal cord. Soon after leaving these points, the anterior and posterior roots unite to form the trunk of a nerve, which is distributed, by means of

branches, to the various organs of that part of the body which this nerve is designed to serve. The spinal nerves supply chiefly the muscles of the trunk and limbs and the external surface of the body.

The tissue composing the nerves is entirely of the white variety, or, in other words, the nerve-fibres; the same as we have observed forming a part of the brain. But the nerves, instead of being soft and pulpy, as in the case of the brain, are dense in structure, being hardened and strengthened by means of a fibrous tissue which surrounds each of these delicate fibres, and binds them together in glistening, silvery bundles. Delicate and minutely fine as are these nerve-fibres, it is probable that each of them pursues an unbroken, isolated course, from its origin, in the brain or elsewhere, to that particular point which it is intended to serve.

3. THE SYMPATHETIC SYSTEM.

This System, like the cerebro-spinal, consists of cells and fibres. It is situated in front and at the sides of the spinal column; its ganglia, which are made up for the most part of small collections of gray nerve-cells and are the nerve-centers of this system, are connected with one another and with the spinal nerves by nerve-cords. The *nerves* given off

from these ganglia chiefly follow the course of the blood-vessels, and are copiously distributed over the heart and about the stomach.

FIG. 57.

THE SYMPATHETIC GANGLIONS AND THEIR CONNECTION WITH OTHER NERVES.

A, *A*, *A*, The semilunar ganglion and solar plexus. *D*, *D*, *D*, The thoracic (chest) ganglions. *E*, *E*, The external and internal branches of the thoracic ganglions. *G*, *H*, The right and left coronary (heart) plexus. *I*, *N*, *Q*, The inferior, middle and superior cervical (neck) ganglions. 1, The renal plexus of nerves. 2, The lumbar (loin) ganglions. 3, Their internal branches. 4, Their external branches. 5, The aortic plexus of nerves.

Branches also ascend into the head, and supply the muscles of the eye and ear, and other organs of sense.

In this manner the various regions of the body

are associated with each other by a nervous apparatus, which is only indirectly connected with the brain and spinal cord, and thus it is arranged that the most widely separated organs of the body are brought into close and active sympathy with each other, so that "if one member suffers, all the other members suffer with it." From this fact, the name *sympathetic system*, or the *great sympathetic nerve*, has been given to the complicated apparatus we have briefly described. Blushing and pallor are caused by mental emotions, as modesty and fear, which produce opposite conditions of the capillaries of the face by means of these sympathetic nerves.

The following from a very interesting writer will be appreciated here:—

"Buried in the hidden recesses of the body, between the spinal column and the great organs of uutrition, there is a double row of small knots of nervous substance, bound together by a series of nerves running from one to another, in succession, from the neck to the base of the column. The whole appears like a long, fine cord, with knots at various distances — a collection of little brains, if I may use a rather crude expression. It is, as the Swiss would say, the 'great council' of this federative republic, which counterpoises that cerebral royalty within us. It has been well named the

great sympathetic nerve, and this it is which makes the laws by which our interior life is governed. The nutritive apparatus of a country, its commerce, its industry, the incessant labor of its citizens, by which the public wealth is built up — and also, let us add, the throbs of the national heart — all this the sympathetic system full plainly shows us should be left to itself. It would be a fine affair if the brain had to watch over the service of the stomach or if, at its convenience, it regulated the movements of the master who disposes of its life. Besides, what would become of the poor body, if the least drowsiness attacked the universal center? Happy is it for us — and let us not be slow to own it — that nature has armed herself against these encroachments of power."— *Macé's The Little Kingdom.*

4. THE FUNCTIONS OF THE NERVOUS SYSTEM.

The Functions of the Brain.— The thin layer of gray matter upon the hemispheres of the larger and smaller brain is intimately associated with mental operations. The reason for the convolutions and fissures on the surface of the brain is evident: they cause the layer of gray matter to be more extensive, and, consequently, other things being equal, to in-

crease in quantity with the increase of convolutions and fissures. There are strong reasons why the main function of the cerebral hemispheres, and more especially that of the gray matter, seems to be the manifestation of intellectual powers and of powers of the will, viz.: —

(1) In the animal kingdom, there is generally a correspondence between the quantity of gray matter, depth of convolutions, and the sagacity of the animal.

(2) The gray matter of the brain is much more smooth during the first period of the infant's life, and its increase corresponds with the development of intelligence.

(3) In diseases which have been known to commence at the circumference of the brain, and to pass toward the center, medical observations have found that the faculties of the mind are affected *first;* while in those diseases which commence in the central parts of the brain, and thence pass towards the circumference, they are affected *last.*

(4) Experiments upon animals show that when the brain is gradually sliced away, the animal grows more dull and stupid as the quantity of brain cut away increases.

Mental Derangement may be caused by (1) imperfect nutrition of the brain; (2) insufficient or

excessive flow of blood toward the brain; (3) a perverse condition of the blood; (4) prolonged sleeplessness; (5) deep affliction or despondency. The usual symptoms of progressing derangement are weakened attention and loss of memory, which should be promptly met by avoidance of physical or nervous excitement, and by proper attention to the body. *Insanity*, a more continuous state of mental derangement, often springs from like sources, but sometimes from hereditary predisposition. Insanity is characterized by lack of appreciation of the proper relations between the self and the external world.

As persons can live though one of their lungs may be seriously injured, so life is not necessarily cut off in case one of the cerebral hemispheres has been damaged.*

The Functions of the Cerebellum, although not

* A pointed iron bar three and a half feet long and one inch and a quarter in diameter, was driven by the premature blasting of a rock, completely through the side of the head of a man who was present. It entered below the temple, and made its exit at the top of the forehead, just about the middle line. The man was at first stunned, and lay in a delirious, semi-stupefied state for about three weeks. At the end of sixteen months, however, he was in perfect health, with wounds healed and mental and bodily functions unimpaired, except that the sight of the eye of the injured side was lost.—*Dalton.*

distinctly known as yet, seem to be the regulation of muscular movement.

The Function of the Medulla Oblongata consists in generating and controlling the motions of respiration and deglutition. It likewise gives rise to certain nerves, which are here called cranial nerves (from *cranium*, the skull). All except two of these important nerves spring from the medulla, or the parts immediately adjoining it; the exceptions are the two nerves taking part in the special senses of sight and smell, which nerves have their origin at the base of the cerebrum.

The *decussation, or* crossing of nerve fibres occurs in this section of the brain. (Fig. 58).

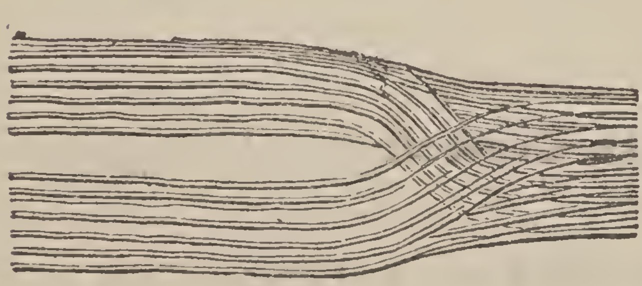

FIG. 58.
NERVE-FILAMENTS.
Decussion with their Sheath.

Hence the fact should be observed in this connection, namely, this cross action does not usually take place in the cranial nerves. Accordingly, when apoplexy, or the rupture of a blood-vessel, occurs in the right hemisphere of the cerebrum, the left side of the body is paralyzed, but the right side of the face is affected; this is because that part of the body is supplied by the cranial nerves

which cross over to the other side in passing down through the medulla.

The brain, cerebellum and the spinal cord can be sliced away one after the other without immediately destroying life; whereas, an interference with the medulla oblongata is followed by instantaneous death.

Functions of the Spinal Cord. — 1. To transmit sensitive impressions from its outer nerves to the brain. 2. To transmit the manifestations of the will from the brain to the spinal-motor nerves, which result in muscular activity. 3. To originate nerve-force independently of the brain whenever a stimulus is applied. Thus, when a stimulus, such as a drop of acid, is applied to the upper leg of a decapitated frog, he brings the toes of the corresponding foot to the place to wipe off the acid, but he will not leap away. In this case an impression has been made upon a sensitive nerve leading to the spinal cord. This sensitive or *sensory* nerve conveyed the impression to the spinal cord, the spinal cord made response to the impression through a *motor* nerve, and this response resulted in the *reflex* action of the foot. So when, independent of any influence of the brain, a small piece of bread is passed into the gullet by voluntary

motion, it will be urged onward to the stomach by involuntary motion — that is, by the reflex action of the spinal cord. The bread here acts as an exciting stimulus upon the spinal marrow, which generates motor power; this motor power is "reflected" back and produces the involuntary movements or reflex action of the muscles whose sensitive fibres were stimulated.

The cord by an accident may be so injured as to cut off all sensation and voluntary motion in the legs, the person apparently lifeless and powerless from the waist downward. By pinching the foot the leg will jerk and even kick with some force. The subject will be unconscious of the act, and unless he is looking at the leg will not know it. This is not due to the muscle itself for if the cord is diseases below the point of injury, this contraction will not occur. To produce this form of nervous action, three things are requisite — (1) a nerve to conduct messages from the surface of the body, one of that which is called sensory, but which is now known to be incapable of awakening sensation; (2) a portion of uninjured spinal cord, which shall reflect or convert impressions into impulses; and (3) a motor nerve to conduct impulses outward to the muscles. The power of the cord to enforce reflex acts resides in the gray matter, into which the reflex nerves enter.

Direction of the Fibres of the Cord.—If one lateral half of the spinal cord be cut, or injured, a very singular fact is observed. All voluntary power over the muscles of the corresponding half of the body is lost, but the sensibility of that side remains undiminished. This result shows that the motor fibres of the cord pursue a direct course, while its sensory fibres are bent from their course. And this has been proved to be the fact; for immediately after the posterior roots — the conductors of sensory impressions — join the posterior columns, they enter the gray matter of the cord, and passing over, ascend to the brain on the opposite side. Accordingly, the sensory fibres from the right and left sides interlace each other in the gray matter; this arrangement has been termed the *decussation*, or crossing of these fibres (Fig. 58). This condition serves to explain how a disease or injury of the cord may cause a paralysis of motion in one leg, and a loss of sensation in the other.

The direction of the anterior, or motor columns of the cord, is downward from the brain. In the cord itself, the course of the motor fibres is for the most part a direct one; but in the medulla oblongata, or upper extremity of the cord, and therefore early in their career, these fibres cross from side to side in a mass, and not separately, as in the case of the

posterior fibres just mentioned. This arrangement is termed the *decussation* of the anterior columns of the medulla.

From this double interlacing of fibres results a cross action between the original and terminal extremity of all nerve-fibres which pass through the medulla — namely, those of all the spinal nerves. Consequently, if the right hand be hurt, the left side of the brain feels the pain; and if the left foot move, it is the right hemisphere which dictates its movement. For the same reason, when a loss of sensation and power of motion affecting the right side of the body alone is observed, the physiologist understands that the brain has been invaded by disease upon its left side. This affection is termed *hemiplegia*, or the "half-stroke." The full-stroke, which often follows the rupture of a blood-vessel in the brain, is called *paralysis*.

The Functions of the Sympathetic System are not fully known as yet. It would appear, however, that while it is intimately connected with the other divisions of the nervous system, it presides over the actions of the alimentary canal, the glands, the blood-vessels and the heart. The heart may be removed from the body, and yet its rhythmical movements will continue for a number of minutes.

This independent motor power on the part of the heart can only be explained by the existence of sympathetic ganglia or centers linked together by delicate nerve filaments, constituting of themselves a distinct nervous system.

An important use of the sympathetic nerve seems to be a communication of one part of the system with another, so that one organ can take cognizance of the condition of every other, and act accordingly. If, for example, disease seizes the brain, the stomach, by its sympathetic connection, knows it; and as nourishment would add to the disease, it refuses to receive food, and perhaps throws off what has already been taken. Loss of appetite in sickness is thus a kind provision of nature, to prevent our taking food when it would be injurious; and following this intimation, we, as a general rule, should abstain from food until the appetite returns.

Functions of Nerves.—If the nerve of a tooth be divided, the tooth has lost its sensibility. If the nerves leading to the biceps be severed, this muscle loses its motor power; it will no longer move the forearm. If these nerves be exposed in their course and irritated, the biceps will be thrown into violent movements, and intense pains experienced as coming from the biceps. These facts show that the nerves,

generally speaking, are endowed with *motor* and *sensory* properties. That is to say, the nerves enable us to seize ordinary sensations, and to perform acts of motion.

There are nerves which are specially engaged in motion, and others, such as the optic nerve, which generate merely sensations. Either class may be injured without any damage to the other. Thus, a blind man rolling his eyes shows that, though his optic nerve is blighted, the motor nerves are in full action. So a limb may be *paralyzed* — that is, deprived of all motion — and yet be very sensitive. If a motor nerve be divided, and a galvanic current applied to the portion of the nerve connected with the muscle, the muscle contracts. This shows that motor nerves act like telegraphic wires.

Cases have been known where soldiers complained of pain in their limbs, which had long before been amputated. This is evidence that sensory nerves act like insulated wires, and, besides, that we refer pain and all other sensations to the parts which are supplied with nerves; we suppose the sensation to exist in the direction from which the nerves communicate it.

The nerves leading from the brain to the eye, ear, etc., etc., are in pairs; also those originating in the spinal cord. The latter are distributed nearly over

the whole body, and are endowed with both motor and sensory properties.

By reference to Fig. 56, it will be observed that each spinal nerve has two roots, a *posterior* and an *anterior*. It is believed that the fibres springing from the posterior root are those of the nerve which convey sensation; and the fibres which originate in the anterior root convey the motory impulse. This is known because when the posterior root is cut the animal loses the power of feeling; and when the anterior root is cut, that of motion.

REVIEW QUESTIONS.

1. What are the *vegetative functions?*
2. What are the *animal functions?*
3. Name the subdivisions of the Nervous System.
4. What is the structure of the Nervous System?
5. Make a drawing of the brain from Fig. 51.
6. What kind of matter predominates in the brain?
7. What is the seat of the mind?
8. What is the weight of the brain substance?
9. Name the coverings of the brain.
10. Describe the Cerebrum.
11. What is the extent of the entire surface of the brain?
12. What is the true source of nerve power?
13. Describe the Cerebellum.
14. What is the *arbor vitæ?*
15. What is the ratio of the Cerebellum to the Cerebrum in size?
16. What is the Medulla Oblongata?
17. Describe the Spinal Cord.
18. Make a drawing of its cross-section, Fig. 56.
19. Name the pairs of Cranial Nerves and tell office of each.
20. How many pairs of Spinal Nerves are there?
21. How do they originate?
22. What can you say of the tissue forming the nerves?
23. What is the Sympathetic System?
24. Where is it?
25. What office does it perform?
26. To what does Mace compare it?
27. Tell the functions of the brain.

28. State the causes of mental derangement.

29. What is *insanity*?

30. What are its causes?

31. May the brain be cut away without causing death?

32. Describe a remarkable incident.

33. What seems to be the functions of the Cerebellum?

34. Tell the functions of the Medulla Oblongata.

35. What is decussation?

36. Discuss the subject of apoplexy.

37. Where is the seat of life?

38. State the three functions of the Spinal Cord.

39. What is *reflex action*?

40. What things are requisite to produce this action?

41. State some uses of reflex action?

42. What can you say as to direction of the fibres of the cord?

43. What are the functions of the Sympathetic System?

44. What are the functions of Nerves?

45. What are sensor nerves? motor nerves?

46. Give a quotation from Dr. Holmes about the Nervous System.

5. THE ORGANS OF SENSE.

Introduction.— The ideas, words and actions of a human being are largely dependent upon the soundness and the training of his sensory organs.

Sensory organs are tools, or instruments, capable (1) of receiving impressions from the outer world, and (2) of making us conscious of those impressions. The means by which consciousness of impressions arises is *sensation*. Thus, the eye with its proper nerves is a sensory organ; it is capable of receiving the impression that a certain ribbon is blue; there is no other organ which can obtain such an impression. The eye, besides being capable of receiving that impression, is also capable of making us conscious of it, viz., the blue color. A man, after his eyes were removed, would be utterly incapable of recognizing the blue tint, although his mind were never so clear.

Sensation, in the present example, is excited by the action of the blue rays upon the retina; so we speak of the sensation of cold, meaning by it the peculiar effect which cold has upon the nerves.

Nearly all sensations come from without the body — that is, from the outer world; they may be called objective sensations. The yellow color of a

lemon, the blue color of a ribbon, are objective sensations. It sometimes happens that the nerves of a sensory organ are affected when there is no objective or outside cause whatever. In this case they make us believe things that have actually no existence. The eye, for example, if closed and pressed upon with a finger, develops a luminous image; this sensation is drawn not from the exterior world, but solely from within the body, hence, is not objective, but *subjective*. The peculiar noise known as the "humming of the ear" is also a subjective sensation.

The sensory organs are five in number, viz., that of *sight*, *hearing*, *touch*, *taste* and *smell*. They are merely the peculiarly shaped termination of a particular nerve. Impressions acting upon this termination, or anywhere upon the nerve, whether coming from within the body or from without, affect it in a way that is peculiar to it, and concerning which nothing positive is known. Thus the eye-ball is so constructed as to collect a great number of rays of light which affect the optic nerve, and thereby produce the sensation of sight. What becomes of this sensation — that is, in what manner it produces the consciousness of sight, and in what manner it ultimately serves intellectual functions, we do not know, and probably never shall. The ear is utterly

blind to the minute waves of light but very sensitive to the ærial waves of sound. So each organ has a distinct structure, in virtue of which it has its particular manifestations; and the different senses may be compared to the various departments of government in a country, all of which together make up the government itself.

TOUCH.

The Sense of Touch is possessed by nearly all portions of the general surface of the body, but it finds its highest development in the hands. The human hand is properly regarded as the model organ of touch. The minute structure of the skin fits it admirably for this form of sensation; the epidermis, or scarf-skin, is fine and flexible, while the dermis, or true-skin, contains multitudes of nerve-filaments, arranged in rows of *papillæ* or cone-like projections, about one one-hundredth of an inch in length. It is estimated that there are 20,000 of these papillæ in a square-inch of the palmar surface of the land. Now, although the nerves of the dermis are the instruments by which impressions are received and transmitted to the brain, yet the epidermis is essential to the sensation of touch. This is shown by the fact that whenever the true-skin is laid bare, as by a burn or blister, the

only feeling that it experiences from contact is one of pain, not that of touch.

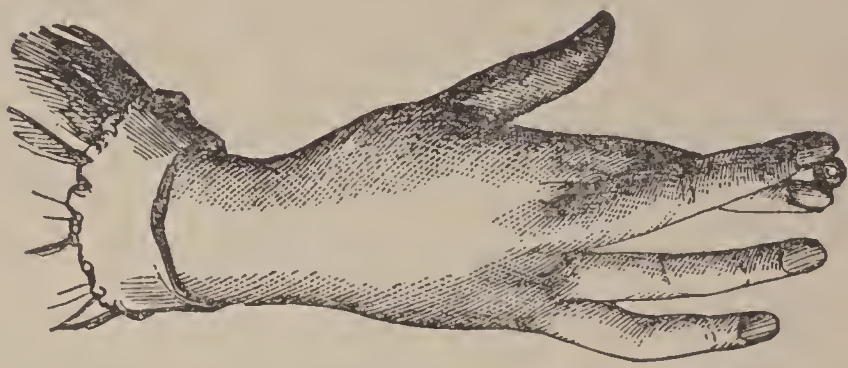

FIG. 59.

The office of the epidermis is thus made evident; it is to shield the nerve-filaments from direct contact with external objects. At the tips of the fingers, where touch is most delicate, the skin rests upon a cushion of elastic material, and receives firmness and permanence of shape by means of the nail placed upon the less sensitive side. Besides these favorable conditions, the form of the arm is such, and its motions are so easy and varied, that we are able to apply the test of touch in a great number of directions. The slender, tapering fingers, with their pliant joints, together with the strong opposing thumb, enable the hand to grasp a great variety of objects; so that, great as are the delicacy and grace of the hand, it is not wanting in the elements of power.*

* The sense of touch cannot always be relied upon. This may be shown by the experiment of Fig. 59.

Pressure, *resistance*, *smoothness*, *roughness*, *hardness*, *softness*, also *cold*, and *heat*, are the most common sensations excited by the sense of touch.

Different portions of the body possess different degrees of sensibility; compare the acuteness of the finger tips with the dullness of the neck. The amount of sensibility is greatly lessened when the skin is stretched.

A person who takes hold of an exceedingly cold iron bar experiences a sensation nearly like that obtained by touching one overheated. The toothache caused by the contact of a tooth with ice cream is the same as that resulting from severe heat applied to the tooth. These well-known facts show that an excess of cold or heat causes pain instead of impression of temperature; the pain is the same, by whichever it may be caused.

Beyond the dermis the nerves are insensible to heat and cold; so the optic nerve, beyond its expansion — the retina — is no longer sensitive to light.

The sense of touch is capable of great development. "Professor Saunders, of Cambridge, who lost his sight when two years old, could distinguish by this sense genuine medals from imitation ones. Other blind men have, by their exquisite touch, been enabled to become sculptors, conchologists, botanists," etc., etc.

THE TASTE.

The Chief Organ of Taste is the upper surface of the tongue; though the lips, the palate, the internal surface of the cheeks, and the upper part of the œsophagus, participate in this function.

The Tongue is a double organ, composed chiefly of muscular fibres, which run in almost every direction. The two sides are so perfectly distinct, that sometimes, in paralysis, one side is affected, while the function of the other remains perfect. It possesses great versatility of motion, and can be moulded into a great variety of shapes. In articulation, mastication, and deglutition, the tongue is an auxiliary to other organs.

FIG. 60.

The Tongue, showing the three kinds of Papillæ — the conical (*D*), the whip-like (*K*, *I*,) the circumvallate or entrenched (*H*, *L*); *E*, *F*, *G*, nerves; *C*, glottis.— *Lankester*.

This organ is abundantly supplied with blood-vessels, having a large artery sent to each side of it. It is also very largely furnished with nerves; it receives nervous filaments from the fifth, ninth, and twelfth pairs of nerves. The branch of the fifth, called the gustatory, is the nerve of taste and sensibility; the twelfth, called the hypo-glossal, of voluntary motion. By means of the ninth, called the glosso-pharyngeal the tongue is brought into association with the fauces, œsophagus, and larynx.

The surface of the tongue is thickly studded with fine *papillae* * which gives the organ a velvety appearance. (Fig. 60). Into these the nerve filament enter and terminate.

Sweetness, *acidity* and *pungency* are sensations most frequently excited by this sense.

Mere contact with the surface of the tongue, however, is not sufficient, but contact with the extremities of the nerves of taste within the papillæ is required. In order that the substance to be tasted may penetrate the cells covering the nerves, it must either be liquid in form, or readily soluble in the watery secretion of the mouth — the saliva. The tongue must be moist also. If the substance be in-

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* By applying strong acids, as vinegar, to the tongue, with a hair pencil, these points will become curiously lengthened.

soluble — as glass or sand — or the tongue dry, the sense of taste is not awakened. In sickness, when the tongue is heavily coated, the taste is very defective, or, as is frequently expressed, "nothing tastes aright."

All portions of the tongue are not alike endowed with the sense of taste, that function being limited to the posterior third, and to the margin and tip of this organ. The soft palate, also, possesses the sense of taste; hence, an article that has an agreeable flavor may very properly be spoken of as palatable, as is often done. All parts of the tongue do not perceive equally well the same flavors. Thus, the front extremity and margin, which is the portion supplied by the "fifth pair" of nerves, perceives more acutely sweet and sour tastes; but the base of the tongue, supplied by the *glosso-pharyngeal* nerve, is especially sensitive to salt and bitter substances. The nerve of the front part of the tongue, as before stated, is in active sympathy with those of the face, while the relations of the other nerve are chiefly with the throat and stomach; so that when an intensely sour taste is perceived, the countenance is involuntarily distorted, and is said to wear an acid expression. On the other hand, a very bitter taste affects certain internal organs, and occasions a sensation of nausea, or sickness of the stomach.

The sense of taste varies greatly in different persons; it depends upon education, habits, and often upon imagination.

The sensations of taste are largely connected with those of other senses, such as smell, touch, and even sight. Thus, when the nose is held tightly closed so as to obtain no smell, the taste of many a substance is rendered difficult to distinguish; and it is very nearly the same if the sense of sight is interfered with.

SMELL.

The Sense of Smell is located in the *nasal* cavities, or air passages, of the nose. This organ is composed of cartilage, mucous membrane, and muscles covered with an integument. It is joined to the skull by small bones. The nasal cavities open behind into the pharynx. The mucous membrane, which lines the interior of the nose, is continuous with the skin externally, and with the lining membrane of the parts of the throat. The entrance of the nostrils is provided with numerous hairs, which serve as guardians to the delicate membrane of the nose.

The nasal cavities (nasal fossæ) are irregular in shape, bounded above by the sphenoid and ethmoid bones of the skull; below by the hard palate. They

are separated from each other by the *septum*, a thin bony tissue, while upon the outer wall of each nostril, in the dried skull, are three projecting processes, termed spongy bones. In life these are covered by a mucous membrane. These *turbinated* bones give more surface for the distribution of the fibres of the olfactory nerve. This nerve ramifies the upper part of the nostrils while in the lower and front part, for the sensibility of touch and pain, are branches of the "fifth pair" of nerves. An irritation applied to the parts where this nerve is distributed occasions sneezing — that is, a spasmodic contraction of the diaphragm, the object of which is the expulsion of the irritating cause. The manner in which the olfactory nerve-fibres terminate is peculiar. Unlike the extremities of other nerves, which are inclosed by a greater or less thickness of tissue, these come directly to the surface of the mucous membrane, and thus are in very close con-

FIG. 61.

SECTION OF THE RIGHT NASAL CAVITY.

tact with the odorous particles that are carried along by the respired air. The surface is at all times kept in a moist condition by an abundant flow of nasal mucus; otherwise it would become dry, hard, and insensitive from the continual passage of air to and fro in breathing.

The Use of the Sense of Smell is to discern the odor or scent of any thing. When substances are presented to the nose, the air that is passing through the nostrils brings the odoriferous particles of matter in contact with the filaments of the olfactory nerves, that are spread upon the membrane that lines the air-passages, and the impression is then transmitted to the brain.

This sense, with that of taste, aids man, as well as the inferior animals, in selecting proper food, and it also gives us pleasure by the inhalation of agreeable odors. The sense of smell, like that of taste and touch, may be improved by cultivation. It likewise varies in different persons.

Sometimes this sense seems to possess a morbid degree of acuteness in respect to odors, which is highly inconvenient and even dangerous. With some individuals, the smell of certain fruits, flowers, cheese, etc., produces nausea and even convulsions.

As a rule, we judge localities with strong odors to

be unhealthy. The escape of illuminating gas is easily detected by its odor, and may be fatal to the inmates of a room. Many strong odors, however, are harmless, while on the oth er hand, quite inodorous atmospheric air may contain the germs of the most dangerous epidemics. Such is the case with the air of low grounds, marshes and swamps. The connection between bad odors and pernicious effects is not yet cleared up; the production of odor is closely connected with that of chemical action.*

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* "I have not seen it anywhere laid down as a general rule, but I believe it might be affirmed, that we are intended to be impressed only sparingly and transiently by ordor. There is a provision for this in the fact that all odors are vapors or gases, or otherwise volatile substances; so that they touch but the inside of the nostril, and then pass away.

"In conformity with this fleeting character of odorous bodies, it is a law in reference to ourselves, to which, as far as I know, there is no exception, that there is not any substance having a powerful smell of which it is safe to take much internally. The most familiar poisonous vegetables, such as the poppy, hemlock, henbane, monk's-hood, and the plants containing prussic acid, have all a strong and peculiar smell. Nitric, muriatic, acetic, and other corrosive acids, have characteristic potent odors, and all are poisons. Even bodies with agreeable odors, like oil of roses, or cinnamon, or lavender, are wholesome only in very small quantities, and, when the odor is repulsive, only in the smallest quantities. So far as health is concerned, the nostril should be but sparingly gratified with pleasing odors or distressed by ungrateful

SIGHT.

The Eye, the apparatus concerned in the sense of sight, consists of the *eyeball*, *optic nerve*, *muscles of motion*, and *protecting organs*. The eyeball is contained within a bony cavity, called the orbit of the eye. In this situation it is not only protected from injury, but is insured the most excellent range of vision. It is acted upon by six muscles, by which the pupil can be directed to almost any point. They are attached, at one extremity, to the bones of the orbit behind the eye and at the other to the eyeball just behind the cornea. It is by the permanent shortening of some of these muscles that we have the condition called *strabismus* or *cross-eye*.

The Eyeball, or globe of the eye, is spherical in shape, and has three sets of coats or tunics: 1st. *The sclerotic and cornea.* 2d. *The choroid, iris, and ciliary processes.* 3d. *The retina.* The *humors*, or contents of the eyeball, are also three in number: 1st. *The aqueous*, or watery. 2d. *The crystalline* (*lens*). 3d. *The vitreous*, or glassy. The sclerotic coat is a white fibrous membrane, and covers about

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ones. No greater mistake can be made in the sick-room than dealing largely in perfumes." — *Wilson.*

four-fifths of the external surface of the eyeball. It is known as "the white of the eye," and anteriorly

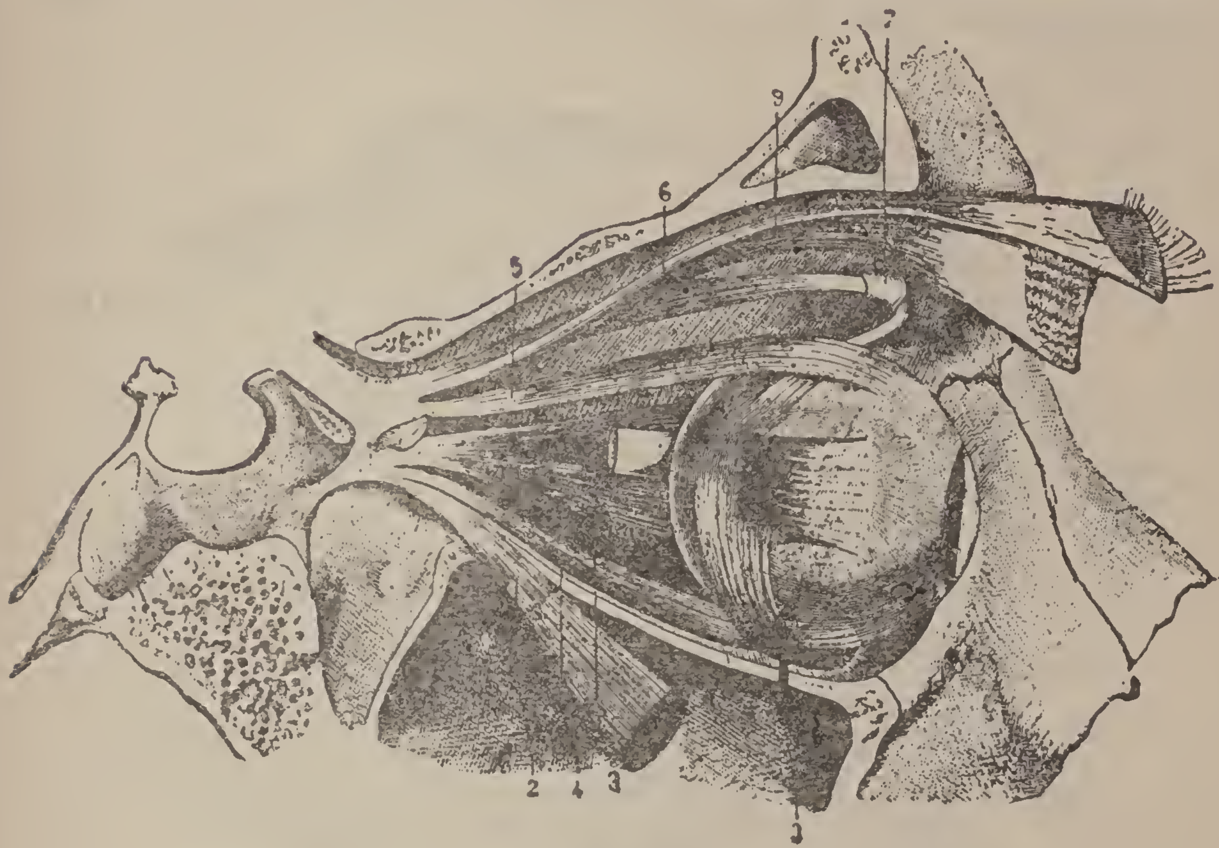

FIG. 62.

THE EYEBALL IN ITS SOCKET, WITH THE MUSCLES THAT MOVE IT.

At the right is seen the projecting nasal bone, with part of the cheek-bone; the eye rests on the latter. Through the transparent cornea, the pupil is faintly seen. 2, external rectus muscle, cut and turned down to expose the back of the eye; 3, internal rectus; 4, inferior rectus; 5, superior rectus; 6, superior oblique, running through the pulley; 7, 8, inferior oblique; 9, elevator of the upper lid. The optic nerve projects from the back of the eye as a cord of considerabie size; a portion has been cut away.

it presents a beveled edge, which receives the circular projecting portion of the eye (cornea) in the same manner that a watch crystal is received by the

groove in its case. The *cornea* is the transparent projecting layer, which forms the anterior one-fifth of the ball of the eye. It is concavo-convex, and

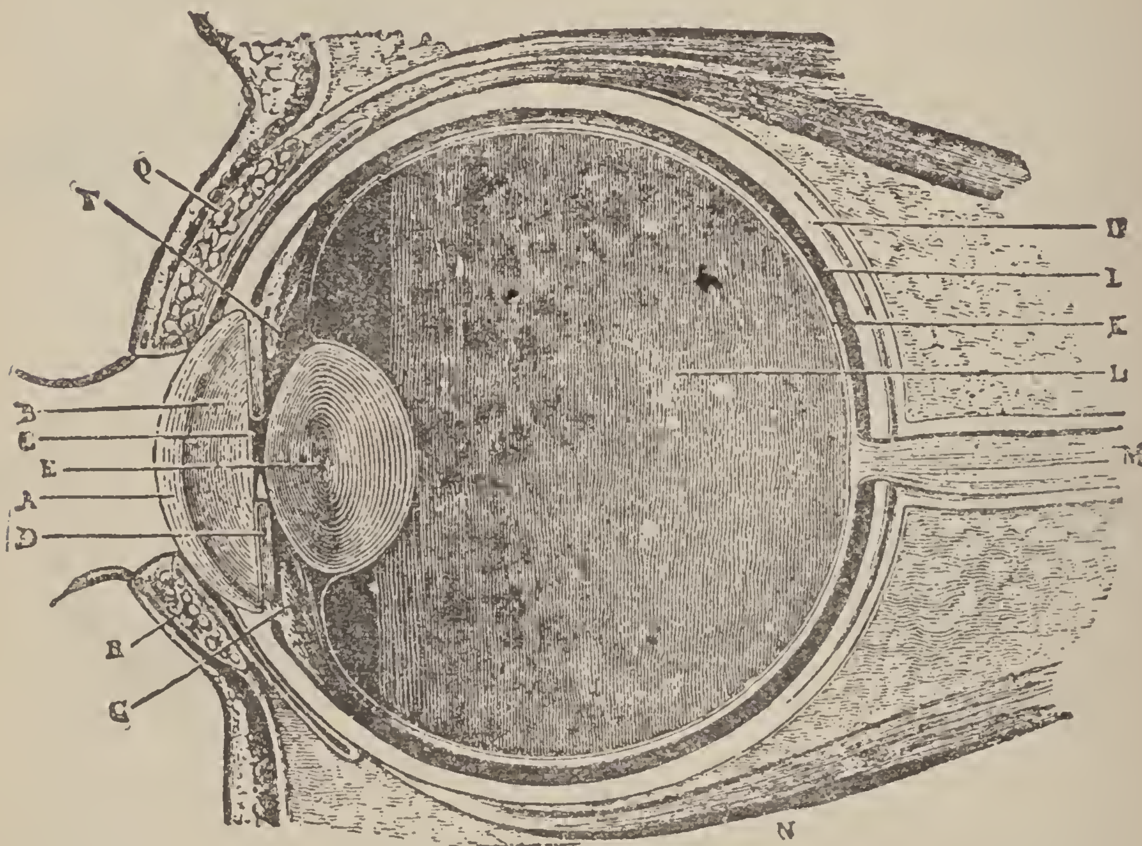

FIG. 63.

VERTICAL SECTION THROUGH THE EYE ON THE MIDDLE LINE.

A, Cornea. *B*, Anterior Chamber. *C*, Pupil. *D*, Iris. *E*, Crystalline. *F*, Zone of Zinn, forming the anterior wall of Canal of Petit. *G*, Ciliary Process and Circle. *H*, Sclerotic. *I*, Choroid. *K*, Retina. *L*, Vitreous Body. *M*, Optic Nerve. *N*, Right Inferior Muscle. *O*, Right Superior Muscle. *P*, Levator Muscle of Eyelid. *Q*, Lachrymal Glands. *R*, Lachrymal Canal.

entirely transparent; its blood-vessels being so small that they exclude the red particles of the blood, altogether, and admit nothing but the serum, by

which it is nourished. The *choroid* is a highly vascular membrane, its external surface being a rich chocolate brown, and its internal a deep black. It invests the posterior five-sixths of the globe, and extends as far forward as the cornea. The *iris* is the circular shaped curtain which hangs behind the cornea, presenting in its center a circular aperture, termed the *pupil.* This membrane is composed of two layers, the radiating fibres of the anterior layer converging from circumference to center, and the fibres of the posterior layer, being circular, surrounding the pupil. By the action of the radiating fibres the pupil dilates, and by the action of the circular fibres, it contracts. The *ciliary processes* are composed of a number of triangular folds, formed by the choroid coat with which they are continuous. The *retina*, the internal

FIG. 64.

FRONT SECTION OF THE EYEBALL.

Viewed from behind and showing Suspensory Ligament, Iris, and Pupil.

coat, is a delicate nervous membrane, upon the surface of which the images of external objects are impressed. Three layers enter into the structure of the retina; namely, the *external*, the *middle* or *nervous*, and the *internal* or *vascular*. The *external* layer is a very thin film; the *middle* layer is the expansion of the optic nerve; and the *internal* consists of the ramifications of a minute artery and its accompanying vein. The *aqueous humor* completely fills the anterior and posterior chambers of the eyeball. The anterior chamber is the space between the cornea, in front, and the iris, behind; while the posterior chamber is the very narrow space bounded by the iris in front, and by the crystalline lens and the ciliary processes, behind. The *crystalline lens* or *humor*, is situated immediately behind the pupil, and is surrounded by the ciliary processes. The lens is composed of a soft substance, arranged in layers, very much after the manner of the coats of an onion. It is double convex in shape and is imbedded in the anterior part of the vitreous humor, from which it is separated by a thin membrane. It is also invested by a thin, elastic, and transparent membrane, known as the capsule of the lens. By the action of the ciliary processes upon the lens and its capsule, the degree of its convexity is changed, and we are thus enabled to view objects at a distance,

as well as examine those very near the eye. Without this ability to change the degree of convexity of the lens, or the power of adaptation, as it is called, vision would be confined to objects at certain definite distances only. The clouding of the lens, or any changes in its structure that prevent the rays of light from passing through it to the retina, constitute the affection known as *cataract* of the eye. The *vitreous humor* fills about four-fifths of the entire eyeball. It is perfectly transparent, and is of the consistence of jelly. It differs from the other humors, in that if it once escapes from the globe, the sight of the eye is irrecoverably lost, while the aqueous humor is capable of being renewed.

The Protecting Organs are the *orbits*, *eyebrows*, *eyelids*, and the *lachrymal* or *tear apparatus*. The *orbits* are the bony sockets in which the eyeballs are situated. They are lined with cushions of fat, and pierced through the bottom by a large hole, giving passage to the optic nerve. The *eyebrows* are so arranged that they prevent the moisture that accumulates on the forhead, in free perspiration, from flowing into the eye, and also shade these organs from too bright a light. The *eyelids*, as every one knows, are two movable curtains placed in front of the eyes. On the outside they have a delicate skin,

with muscular fibres beneath, and a narrow cartilage on their edges, serving to preserve the shape of the lid. The lids are lined with a delicate membrane, which is reflected over the front of the eye. This membrane is called the *conjunctiva*, and is subject to very severe forms of inflammation known as *conjunctivitis*. The natural secretion of the conjunctiva is a fluid, which serves the purpose of lubricating the eye, and of allowing the lids to open and shut without friction. The edges of the lids are furnished with a row of hairs, called eyelashes, which naturally curve upward from the upper lid, and downward from the lower, so that they may not become entangled with each other in the closure of lids. Their purpose is that of protecting the eyeball from dust, and of spreading the lubricating fluid equally over the surface of the eye. The *lachrymal apparatus* which secretes the tears consists of the *lachrymal gland* with its *ducts*, *lachrymal canals*, and the *nasal duct*. The *lachrymal gland* is situated at the upper and outer angle of the orbit. It is flattened and oval in shape, about three-quarters of an inch in length, and has, passing from it, ten or twelve small ducts which open upon the upper lid, where they pour upon the conjunctiva the tears. This secretion is kept up continually, walking or sleeping, thus causing the eyes to be

constantly moist. The *lachrymal canals* begin at minute openings upon the free borders of each eyelid, near the inner angle of the eye, by two small orifices called *puncta lachrymalia* (tear points). Each of these points communicates with the nasal duct. The *nasal duct* is a short canal, about three-quarters of an inch in length, directed downward and backward from the inner angle of the eye to the inferior channel of the nose. The tears are therefore secreted by the lachrymal glands, conveyed to the eye by the small ducts, taken up by the puncta lachrymalia into the lachrymal canals, and thence carried through the nasal ducts into the nasal passages.

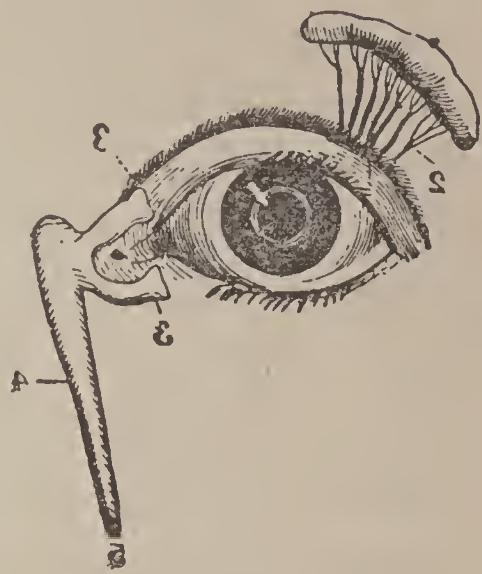

FIG. 65.

1, The lachrymal gland. 2, Ducts leading from the lachrymal gland to the upper eyelid. 3, 3, The puncta lachrymalia. 4, The nasal sac. 5, The termination of the nasal duct.

The Physiology of Vision.—As regards the functions of the different parts of the globe of the eye, the sclerotic coat not only gives form to the organ,

but, by its dense fibrous structure, gives protection to the interior and more delicate parts. The choroid coat consists chiefly of a tissue of nerves and small blood-vessels; the latter give nourishment to the eye. Another very important office of this coat is to absorb the rays of light immediately after they have passed to the retina. This is effected by the inner lining of its surface, which is composed of black pigment. Light would be too intense were it not for this provision, and vision confused and indistinct. The iris, by means of its powers of expansion and contraction, regulates the amount of light admitted through the pupil. Persons unacquainted with the structure of the eye, are sometimes liable to be mistaken as to the nature of the pupil, as it appears like a black spot, instead of an opening. The aqueous, crystalline, and vitreous humors, together with the cornea, are transparent, and the rays of light pass through them to fall upon the retina. The office of the cornea and these humors, is to refract the rays of light in such proportion as to direct the image in the most favorable manner upon the retina. The retina receives the impression of the rays of light, which leave upon it the image of an object at which we look. The impression thus produced by the reflected light is transmitted

by the optic nerve to the brain. This constitutes vision.*

Visual Phenomena of Light. — The science of optics, however, treats not only of vision, but also of the properties and phenomena of light. To completely comprehend the theory of vision, a knowledge of the anatomy of the eye, alone, is not sufficient. While it is not our purpose to enter minutely into the discussion of a subject which properly falls within the domain of natural philosophy, rather than of physiology, there are a few simple laws concerning the nature of light, by which,

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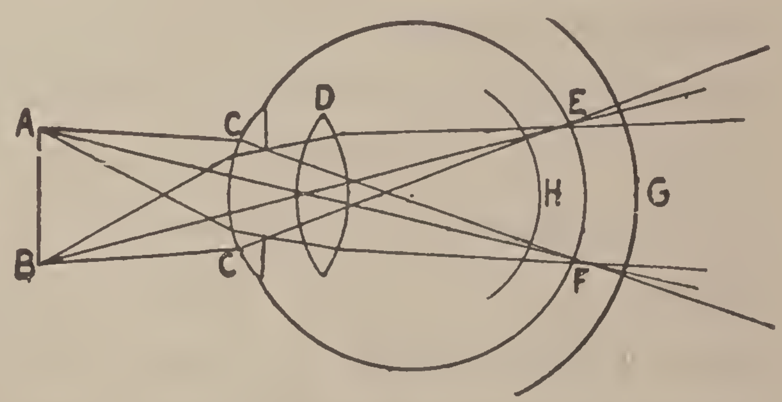
* Color-blindness.— "Daltonism, or color-blindness, receives its name from the eminent English chemist, who described this infirmity as it existed in his own case. It arises from an unnatural condition of the organs of vision which prevents the discrimination of certain colors. Some persons will mistake red for green; so that ripe cherries on a tree appear the same as the leaves; others recognize only black and white. Persons thus affected are sometimes incapable of discriminating musical tones. The healthy eye ordinarily fails to discriminate between certain colors, blue and green especially, when viewed by artificial light. But even this may in a measure be overcome by training, so that an expert dealer in silk obtains a knowledge of the shades of blue, green, and violet, which is proof against the confusing influence of gaslight and tinted curtains. The eyes of persons who have much to do with colors are more liable to become overstrained than those dealing chiefly with rays of white light." — *Flint's Physiology* (*in part*).

if the reader briefly directs his attention, the phenomena of vision may be easily explained. Light is defined as that principle, or substance, which enables us to see any object from which it proceeds. If a luminous substance, as a burning candle, be carried into a dark room, the objects in the room become visible, because they reflect the light of the candle to our eyes. A *ray* is a single line of light, as it comes from a luminous body. A *beam* of light is a body of parallel rays. A *pencil* of light is a body of diverging or converging rays. Luminous bodies emit rays, or pencils of light, in every direction, so that the space through which they are visible is filled with them at every possible point. The sun, therefore, illuminates every point of space within the whole solar system. A light, as that of a light-house which can be seen from the distance of ten miles in one direction, fills every point within a circuit of ten miles from it with light. The rays of light move forward in straight lines from the luminous body, and are never turned out of their course, except by some obstacle; *yet when a ray of light passes obliquely from one transparent body into another of a different density, it leaves its linear direction, and is bent, or refracted, more or less, out of its former course.* It is, therefore, by the refracting power of the aqueous humor and the crystalline lens

of the eye, the most perfect of all optical apparatus, that the pencils of rays are so concentrated as to form a perfect picture of the object on the retina. The reader will now readily understand the phenomena of vision, by referring to the accompanying diagram. Rays of light reflected from the points *A* and *B* are slightly refracted inward entering the anterior chamber at *C C*, which contains the aqueous humor. Upon entering the crystalline lens *D*, they are still further bent, until at length these lines, meeting together at one point, form the focus *E F*. The highest point becomes lowest, and *vice versa;* or, in other words, the object is inverted; and what we call the upper end of a vertical object, is the lower end of its picture on the retina, and so the contrary. In the perfect eye, the point of meeting, or focus of the lines, is immediately on the retina, or inner lining of the eye.



Should the posterior wall of the retina be too close to the crystalline lens, the lines would not meet; therefore, the vision would be blurred and confused, as on the line *H*. Should the retina be at the line *G*,

the rays having come to a focus at *E F* will again diverge, and will thus result in an imperfect vision. In some conditions of the eyeball, as in short or far-sightedness, the convex portion of the eye, the cornea and the lens, which refract the light, are either too convex, or not sufficiently so, and thus the image is imperfectly reproduced on the retina. When the refraction of the rays of light is too great, as in over-convexity of the cornea, or the crystalline lens, or of both, the image is formed a little in front of the retina, and persons thus affected cannot see distinctly, except at a very short distance. This infirmity is called shortsightedness, or *myopia.* The defect is in a great measure obviated by the use of concave glasses, which scatter the luminous rays, and thus counterbalance the two strong refracting powers of the organ. When the different parts of the eye are not sufficiently convex, the image is formed beyond the retina, and thus only distant objects are distinctly seen. This defect is known as far-sightedness or *presbyopia.* It is usually a consequence of old age, and is remedied by wearing spectacles with convex glasses. Thus it is seen, that to view objects at a distance a less convex lens is needed than in the examination of articles very near the eye. The perfect eye, however, is a wonderful piece of mechan-

ism, possessing the singular and ingenious power of adaptation to widely different distances. This peculiar accommodation is effected by changes in the *form* of the lens. It has been proved that when the eye is turned from a distant to a near object, the antero-posterior diameter of the lens becomes elongated, and the anterior surface becomes more convex, while the opposite changes take place in turning the eye from a near to a distant object.*

In conclusion, the optical apparatus of the eye comprises two solid substances — a horny and a glassy one — and two liquids, all four serving the purpose of lenses. There is no artificial contrivance which approaches it in excellence.

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* Close the left eye; with the right eye look steadily at the cross below, holding the page at a distance of about twelve inches.

In this position both dot and cross will be seen distinctly. But if the book be slowly brought nearer to the face, the right eye being still fixed upon the cross, the dot will disappear during an instant, and as the book approaches the face, becomes visible again. Now, during the instant that the dot vanished out of sight, the image of the dot was on the *blind spot* of the retina — that is on the region of the retina where the optic nerve enters the choroid.

HEARING.

The Ear, the organ of hearing, is probably the most complicated in the body, and, next to sight, the most important. It is composed of three parts:

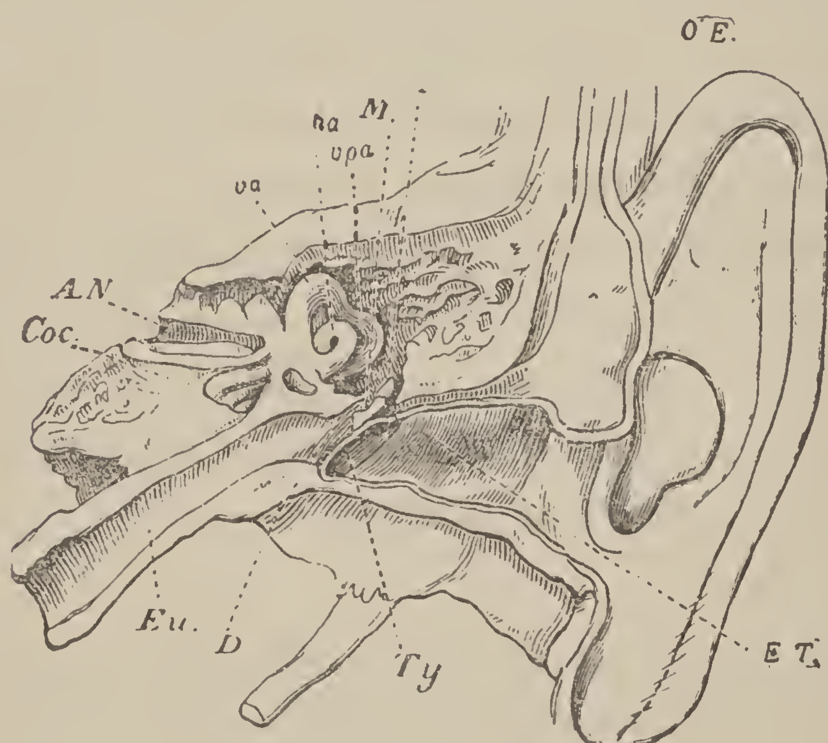

FIG. 66.

THE EAR — TRANSVERSE SECTION THROUGH THE SIDE WALLS OF THE SKULL.

OE	Outer Ear.	*M*	Hammer.
ET	External Tube.	*I*	Anvil.
Ty	Tympanic Membrane.	*va, ha, vpa*	Semicircular Canals.
D	Drum or Tympanum.	*Coc*	Cochlea.
Eu	Eustachian Tube.	*AN*	Auditory Nerve.

1st. *The external ear.* 2d. *The tympanum*, or *middle ear.* 3d. *The labyrinth*, or *internal ear.* The *external ear* consists of two parts; namely, the *pinna*,

or wing, and the *meatus auditorius* (auditory canal). The *pinna* is the *pavilion*, or the prominent external part of the organ of hearing. It presents many furrows and ridges, arising from the folds of the cartilage that forms it. The *meatus auditorius* is a partly cartilaginous and partly bony canal, about an inch in length, extending inward from the pinna to the *membrana tympani* ("drum" of the ear). It is lined with an extremely thin cuticle, and in the interior of the tube are found a number of short and rather stiff hairs, which obstruct the entrance of insects and other foreign substances. There are a number of small follicles beneath the cuticle, which secrete the *ear wax*. The *membrana tympani* is a thin semi-transparent membrane, about three-eighths of an inch in diameter, inserted in a groove of the meatus near its termination. It is placed obliquely across the tube, having a concave surface toward the meatus, and a convex toward the tympanum. The *tympanum* is an irregular bony cavity, bounded externally by the membrana tympani, internally by its inner wall, and in its circumference by the petrous (stony) portion of the temporal bone and mastoid cells. The tympanum contains four small bones, named, respectively, the *malleus*, *incus*, *stapes* and *orbicularis*. There are several openings in the middle ear, among which is

the *eustachian tube*, a canal of communication extending obliquely between the pharynx and the anterior circumference of the tympanum. It is partly fibro-cartilaginous, and partly bony in structure. The *labyrinth* consists of a membranous and bony portion, the latter presenting a series of cavities which are channeled through the substance of the petrous bone. It is divided into the *vestibule*, *semicircular canals*, and *cochlea*. The *vestibule* is situated immediately within the inner wall of the tympanum, and consists of a small, three-cornered cavity. The *semicircular canals* are three bony passages which communicate with the vestibule, into which two of them open at both extremities, and the third at one extremity. The *cochlea* forms the anterior portion of the labyrinth. It is about one and a half inches in length, and forms a bony and gradually tapering canal, which makes two and a half turns, spirally, around a central axis, called the *modiolus*. The *membranous labyrinth* is a perfect counterpart, with respect to form, of the bony vestibule, cochlea, and

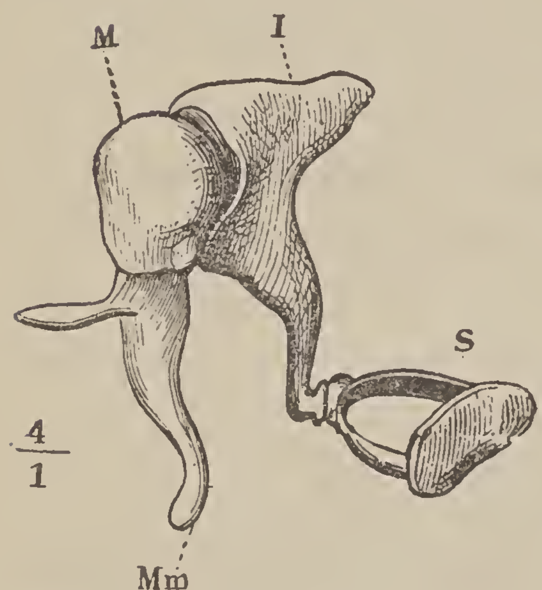

FIG. 67.
The Small Bones of the Ear.

semi-circular canals. There are two small, elongated sacs within this labyrinth, which are filled with water. The *auditory nerve* enters the temporal bone upon its internal surface, and divides into two branches at the bottom of the cavity of the internal ear. These branches, after radiating in all directions, finally terminate upon the inner surface of the membrane in minute papillæ, resembling those of the retina of the eye.

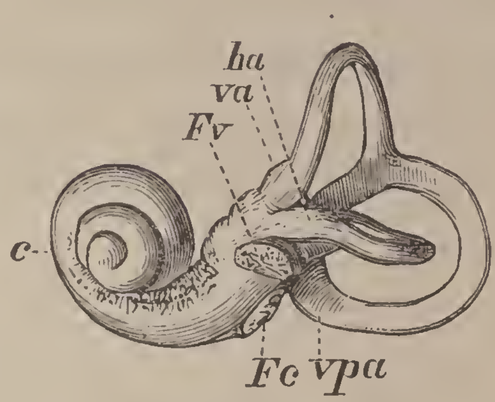

FIG. 68.
The Labyrinth — (ext. view).

The pinna, or that part of the external ear which projects from the head, performs the function of collecting sounds and reflecting them into the auditory canal. The drum of the ear (membrana tympani) not only moderates the intensity of sounds, but serves to facilitate their transmission to the parts interior. It has no opening in its healthy state, and it is so arranged that it may be relaxed or tightened. There being no opening in it, the apprehension which is often expressed, that bugs and insects may penetrate within the deeper structures of the ear, and even to the brain, is without real cause; foreign bodies in the ear, of course, produce intense pain; but that is owing to the irritation of the exceedingly

sensitive membrana tympani. The office of the *eustachian tube* is to admit air from the mouth into the tympanum, which renders the pressure on each side equal, thus keeping its membrane in a proper state of tension. Therefore, if the mouth is kept open while a cannon is discharged near by, the shock is lessened.

Thus, the vibrations of air are collected by the external ear, and conducted through the auditory canal to the drum of the ear; from this membrane the vibrations pass along the chain of small bones to the internal ear; in the internal ear these are at once taken up by the fluid in the vestibule and transmitted to the remaining liquids in the various canals composing the labyrinth. The motion of the liquids causes the minute fibres and hair-like terminations of the auditory nerve, which are floating freely in the liquids, to vibrate; and their vibrations are carried by the auditory nerve to the brain.

6. HYGIENE AND DISORDERS OF ORGANS OF SENSE.

The Organs of Sense are the ways, or machines, by which the mind, which acts within the man, gets all its knowledge of the world. Without these nothing

could be known of all the interesting and beautiful things about us. How dark and lonely would life be! Since so much depends upon these organs it certainly behooves us to look to the proper care of them. For this reason we think it wise to consider here some of the most important rules for their health.

Hygiene of the Sense of Touch. — Much of pleasure or of pain may result from the condition of this organ.

(1) *The Condition of the Epidermis Determines the Character of the Impression made upon the Nerves.* — When the cuticle has become thick and hard, like horn, as on the inside of the mason's hand, it enables him to ply his tools without much suffering, because the thickened cuticle diminishes the impressions made upon the nerves.

When the cuticle is very thin and delicate, as on the hand of the lady who is unaccustomed to manual labor, let her pursue some manual employment for several hours, and the extreme tenuity, or thinness of the cuticle, will not protect the nerves and parts below from becoming irritated and inflamed.

When the cuticle is removed by blistering or abrasion, the pain indicates that the naked nerves

are too powerfully stimulated by the contact of external bodies. When the cuticle is coated with impurities, blended with the secretion from the oil-glands, the sensibility of the skin is lessened.

(2) *Habit has much to do with the Nerves of Touch as to the Acuteness of Impression.*—By long practice the blind girl is enabled to distinguish very readily the little points and angles of the raised letters and other characters on the page of the book for the blind. So acute has this sense become by training that the blind and deaf person is able to understand what is spoken to her by putting her finger-tip upon the lips of the person speaking.

Hygiene of the Sense of Taste.—Some one has said: "The tastes of men present the most singular diversities, partly the result of necessity and partly of habit or education."

(1) *Taste is Largely Dependent upon Habit.*—Not infrequently those articles which at first were disgusting become highly agreeable by persevering in the use of them, as in learning to chew tobacco and medicinal roots.

(2) *The Sense of Taste Becomes Impaired by the Immoderate use of Stimulants and Condiments.*—These indulgences lessen the sensibility of the nerves.

In children this sense is usually acute, and their preference is for food of the mildest character.

Hygiene of the Sense of Smell.— This sense, like all the others, is for benefit and pleasure. It aids in selecting food and gives satisfaction in the inhaling of agreeable odors.

(1) *The Sense of Smell may be Improved by Use.*— Thus the Indian can easily distinguish different tribes and different persons of the same tribe by the odor of their bodies. Next to touch, smell is of great importance to the blind.

(2) *Smell Requires for Acuteness that the Brain and Olfactory Nerve, also the Lining Membrane of the Nose, be in a Healthy Condition.*— Any influence that diminishes the sensibilty of the nerves, thickens the membrane or renders it dry, impairs this sense. The mucous membrane of the nasal passages is the seat of a chronic catarrh. This affection is difficult of removal, as remedial agents cannot easily be introduced into the windings of these passages. Snuff and many other articles used for catarrh produce more disease than they remove.

Hygiene of the Sense of Sight. — The appreciation of color, form, size, distances, etc., is due to the

sense of sight almost entirely. As to value some are disposed to rank it first among the senses.

(1) *The Eye should be Used and should be Rested.*— If we look intently at an object for a long time, the eye becomes wearied, and the power of vision diminished. The observance of this rule is particularly needful to those whose eyes are weak, and predisposed to inflammation. On the contrary, if the eye is not called into action, its functions are enfeebled.

(2) *Light should fall upon the Object and not into the Eye.* — The position of the body should be such that the light will come from the left side or the rear; *never from the front.*

(3) "*Sudden Transitions of Light should be Avoided.* — The iris enlarges or contracts, as the light that falls upon the eye is faint or strong; but the change is not instantaneous."

(4) *The Direction of the Vision should receive Attention.* — If the eye is turned obliquely for a long time in viewing objects, it may produce an unnatural contraction of the muscle called into action. This contraction of the muscle is termed *strabismus*, or cross-eye. The practice of imitating the appearance of a person thus affected, is injudicious, as the

imitation, designed to be temporary, may become permanent.

The vision of a "cross-eye" is always defective. In general, only one eye is called into action, in viewing the object to which the mind is directed. This defect can be remedied by a surgical operation, which also corrects the position of the eye.

(5) *Particles of Dust, etc., which may get into the Eye, should be Removed at Once.*—Rubbing only irritates and increases the sensitiveness. If the eye be shut for a few moments that the tears may accumulate and the upper lid then lifted, the foreign body will very likely be washed away.

(6) *The Eye should be Bathed with hot Water.*—This should be done when the eye is known to be weak or becomes weary, and is best performed in the following manner.

Set an ordinary tumbler or drinking goblet in a plate. Put a teaspoonful of table salt in the glass. Now fill the goblet with hot water until it is "brimfull." See that the water is as hot as it can be borne. Now place the head over the tumbler, letting the eye down into the water till the head rests upon the glass. As the water cools pour in more hot water, keeping the temperature up to the highest point endurable.

Do this for twenty to thirty minutes each evening for several days. Great benefit will result.

Hygiene of the Sense of Hearing.— The delicacy of the ear is such that it must have very great care. Its location far within the large temporal bone of the skull is nature's precaution with regard to this organ.

(1) *Avoid Boxing the Ear.*— Entire deafness may be produced by a fall or a heavy blow over the ear. There are cases on record of children having their hearing permanently injured by such treatment.

(2) *Do Not Remove the Wax* which is secreted at the entrance to the canal of the external ear. Nature attends to the cleaning of the ear. The wax secreted keeps out foreign bodies and in time dries up and falls out of its own accord, leaving the ear clean and unharmed. In health the ear is never dirty. The canal leading into the drum of the ear is here referred to. If we attempt to wash it we either make it dirty by spreading the wax and dust about on the walls of the canal or we irritate and injure it. One of the most hurtful things is to introduce the corner of the towel, screwed up, and twist it around.

(3) *Hearing May be Impaired by Obstruction of the Eustachian Tube.*— The closure of this canal

diminishes the vibratory character of the air within the tympanum, in the same manner as closing the opening in the side of a drum. For the same reason, enlarged tonsils, inflammation and ulceration of the fauces and nasal passages during and subsequent to an attack of scarlet fever, and the inflammation attending the "sore throat" in colds, are common causes of this obstruction.

The treatment of such cases of defective hearing, is to have the tonsils, if enlarged, removed by a surgeon; for the inflammation and the thickening of the parts remedial means should be applied, directed by a skillful physician. The nostrums for the cure of deafness are generally of an oleaginous character, and may be beneficial in cases of defective hearing caused by an accumulation of wax upon the drum of the ear, but in this respect they are no better than the ordinary animal oils.

(4) *Direct Draughts into the Ear Should be Avoided.*—Earache in children is often caused by this thing. And deafness has been known to result from letting rain and sleet into the ear.

7. THE MIND.

We have now seen that man possesses a passive framework composed of bones, which form the levers

by which he accomplishes his movements. These levers are acted upon by the muscles, which thereby become the proper organs of motion. These, in turn, are controlled to a greater or less extent by the nervous system. The bones, muscles, sensory organs and nervous system have very properly been called the "Animal Apparatus of Life;" they are found in all the higher animals.

Now, there is another function apparent in the human body, in virtue of which a constant *building-up* or *repairing* of these essentials of animal life is going on within the body, which is called for by the continuous wear and tear of bones, muscles and blood. This function is performed by organs which (1) make blood such as the alimentary canal and the lymphatics; (2) keep the blood in circulation, as the heart; and (3) maintain it in a pure state, as the lungs. These organs have been comprised under the head of "Organic Apparatus of Life," and are also influenced by the nervous system.

The animal apparatus of life intimately connects man with the higher animals; the organic apparatus of life with the vegetable kingdom.

Many of the Higher Species of animals have been greatly changed by domestication. Their ferocious habits have been modified, their instincts improved,

their intelligence developed; but in spite of all this, domesticated races, when left to themselves, after a few generations return to their original wildness. And the superiority of training which an individual animal may have received never benefits his species or race.

With the Human Being it is very different. Man is gifted not only with an unlimited capacity for mental accomplishment, but also with a never-ending desire to acquire new mental attainments. And individuals of ability and talent seldom fail to benefit their race. From these gifts spring the eagerness of the hnman being for *education.* Education consists chiefly in repressing the lower habits of human nature, and in developing its nobler qualities.

Beyond all this there exists yet something more elevated, though more difficult to analyze, viz.: the faculty which enables us to conceive the idea of the infinite and our relations to the infinite, by which we possess aspirations after *Truth*, *Goodness*, *Right*, and *Beauty*.

If the Capacity for, and Desire after, mental accomplishment, referred to above, be expressed by

the term *Mind*, we must recognize (*a*) that the mind is greatly dependent upon the condition and the state of health of the body, and (*b*) that the body, in turn, is easily affected by the mind. There are many familiar facts to testify to this, among which may be mentioned as proofs of *a*: (1) The necessity of proper food to nourish the brain: that is, of pure blood with an abundance of oxygen. Wherever this is wanting, mental activity decreases. (2) The effect of local affections of the brain, as when a person has received a severe blow on the head. (3) The effect of intoxication, or (4) of poison, or (5) of fever, or other bodily disorder. And among the numerous proofs of *b* we have: (1) The well-known effects of anxiety, fear or joy on the body. (2) The injurious effect of mental depression on bodily functions. (3) The self-restraint exerted by the body in obedience to efforts of the will.

Attention.— Every individual has a certain capacity of concentrating his faculties upon a task which he wishes to perform. Thus, he may wish to acquire knowledge, to repress his anger, to control his habits, or to observe strict honesty in his dealings with others; but for any and all of these activities he needs a certain power of will. This power of will he must bring to bear upon his faculties in

order to be successful. If all his faculties are directed upon any one activity at a time, as for example, upon the acquisition of mathematics, he nearly excludes them from any other activity, and is then said to be *attentive*. Attention, therefore, is the concentration by the power of will of all the faculties upon some one activity to the exclusion of others. Thus, a young person who is bent over his slate, concentrating all his activities upon an arithmetical problem, is almost unaware of what is going on around him. He will deprive the sensory organs of nearly all their faculties, which are now spent in *inward* attention. On the other hand, a countryman visiting a large town for the first time, does not follow any particular train of thought, but has his senses busily engaged by the novelties with which he is impressed at every step. His will does not direct his faculties to any special activity; they are devoted to his sensory organs, and, consequently, his attention is wholly *outward*.

Perception.—*A sleeping person* may unconsciously start at a loud noise, and then resume his former state of sleep. His sensation was correct; he was conscious of it, but he had no distinct *perception* regarding the source or nature of the sound, because he bestowed no attention upon it. Or, if the

young student, referred to above, had been less absorbed by his mathematical problem, he might have unconsciously heard cries outside of his room, and yet not have had a distinct perception of them; and having finished his task, and hearing the cries again, this time with his full attention directed toward them, he may dimly remember to have heard them before. While, then, a *sensation* is an impression upon a conscious state of mind, a *perception* is an impression upon a conscious state of mind accompanied by attention; or, perception = sensation + attention. From the preceding it will be clear that a person having heard a loud report at a distance repeated several times, in speaking about it will, with perfect propriety, describe the *sensation* which the sound produced in *himself*, and which, as yet, he may attribute to the roaring of cannon, or thunder, or to an explosion. Now, let him arrive on the spot from whence the noise proceeded. Suppose it to have been due to the practice of artillery. He will then *perceive* the source and the nature of the report, and thus obtain a distinct *perception* of the cannon, which he may afterwards describe. He has now learned something *outside of himself*, and his mind is no longer engrossed with its own sensation.

Ideas.— After his return, the same person can accurately picture the cannon and represent to him-

self its effect; that is he has retained a *mental representation* or *idea* of the object and its effect. This idea he can afterwards reproduce in audible or visible signs — words; or, if he is an artist, he can paint it. *An idea is the mental representation of an object;* it calls for a higher mental activity than perception.

A succession of ideas gives rise to *thought*. The conscious mind is incessantly engaged in thought. We might continue, and treat of the laws of thought, emotion, habit, will, sleep, and dreams, but the limits of the present volume have now been attained. For further information, the young student should peruse works on psychology.

REVIEW QUESTIONS.

1. What is the organ of Touch?
2. What can you say of its fitness?
3. What is the difference between touch and pain?
4. Where is the touch most delicate?
5. Of what use is the *epidermis*?
6. What are the terminations of the nerves of touch?
7. What is the organ of Taste?
8. Does the tongue give more than the sense of taste? What?
9. To what other sense is that of taste allied?
10. Describe the organ of Smell!
11. What is the use of the turbinated bones?
12. How does the olfactory nerve terminate?
13. How do we smell?
14. Compare acuteness of this sense in man with that of animals.
15. Name the parts of the organ of sight.
16. Draw a cross section of the eyeball.
17. Describe each of its parts.
18. What is *myopia*? *presbyopia*? *hyopia*?
19. Draw a vertical section of the ear.
20. Name parts and tell location.
21. Discuss the care of and give rules of hygiene for the organ of Touch.
22. Discuss the care of and give rules of hygiene for the organ of Taste.
23. Discuss the care of and give rules of hygiene for the organ of Smell.
24. Discuss the care of and give rules of hygiene for the organ of Sight.
25. Discuss the care of and give rules of hygiene for the organ of Hearing.
26. What is Attention? Perception?

BLACKBOARD OUTLINE.

THE NERVOUS SYSTEM.

I. **Structure.**
  1. Kinds of matter.
  2. Divisions.

II. **Organs of the Nervous System.**
  1. The Brain.
     The Cerebrum.
     The Cerebellum.
     The Medulla Oblongata.
  2. The Spinal Cord.
  3. The Nerves.
     The Cranial Nerves.
     The Spinal Nerves.
  4. The Sympathetic System.
     Ganglia.
     Nerves.

III. **Functions of the Nervous System.**
  1. The Brain.
  2. The Spinal Cord.
     Decussation of Fibres.
     Roots of Nerves.
     Reflex Action.
  3. The Nerves.
     Motor and Sensor Nerves.
  4. The Sympathetic System.

IV. **Hygiene and Disorders of the Nervous System.**

V. **Organs of Sense.**
  1. Touch.
  2. Taste.
  3. Smell.
  4. Sight.
  5. Hearing.

VI. **Hygiene and Disorders of the Organs of Sense.**

IX.

HYGIENE—ALCOHOL—STIMULANTS—NARCOTICS—THEIR EFFECTS.

No vice is more hereditary than intemperance.—Dr. Yellowlees.

There is no such thing as a temperate use of spirits. In any quantity they are an enemy to the human constitution. Their influence upon the physical organs is unfavorable to health. They produce weakness, not strength; sickness, not health; death, not life.—Dr. Alden.

Vice is a monster of so frightful mien,
As to be hated needs but to be seen;
But seen too oft, familiar with her face,
We first endure, then pity, then embrace.—Pope.

IX. Hygiene.—Alcohol—Stimulants—Narcotics—Their Effects.

1. ALCOHOL.

Alcohol, one of the most active stimulants, not only from its effects but from its wide occurrence, being found in nearly all intoxicating drinks, leads every other drug in its far-reaching influence for mischief and evil. Were the thousands of ruined homes, the untold numbers of blasted lives, the sorrows, sins, numberless crimes, murders, and deaths, that follow yearly in the train of this fell destroyer, brought into panoramic review before us, what a hell-born picture it would be!

Properties.—Alcohol is a clear, watery-like, volatile fluid, having a hot, pungent taste and a penetrating odor. It burns with a pale blue flame and intense heat. It is specifically lighter than water, having a specific gravity of about 0.8, which means that a given volume of it weighs only about $\frac{8}{10}$ as much as the same volume of pure water. Its boil-

ing point is lower than that of water, being about 175° Fahrenheit (that of water being 212° F.).

It has a strong attraction for water, and mixes with it in all proportions. What is known as the ordinary alcohol of commerce is pure alcohol mixed with water.

A drop of it placed upon the skin produces the sensation of cold, which is due to its rapid evaporation.

Manufacture. — Alcohol can be made from any substance containing sugar. This fact is readily seen from comparing the two classes of sugars: *Sucroses* $C_{12}H_{22}O_{11}$ and *glucoses* $C_6H_{12}O_6$ with *methyl hydrate*, CH_3OH and *ethyl hydrate* C_2H_5ON, which is *common alcohol*, each compound being a union of hydrogen, oxygen, and carbon.

Uses. — Since it does not freeze, it is used in thermometers. It is also used in levels, and finds a wide use in the arts and sciences, especially in the science of medicine. There are over a dozen different kinds of alcohol, but we shall deal with what is termed *common alcohol*, called also *spirits of wine*.

Alcohol is used in the arts for many useful purposes. On account of its great capacity of dissolv-

ing substances, it is used as a solvent of rosins, cements, pharmaceutical preparations, and for the manufacture of perfumes and essential oils.

On account of its capacity for preserving vegetable and animal fibres, it is used to preserve anatomical specimens and articles of food.

On account of its stimulating powers it is used by physicians in small quantities greatly diluted with water, to promote or stimulate the action of organs such as the heart or stomach. But instead of using pure alcohol diluted with water, pure light wines are usually recommended by physicians on account of their flavor, as all such wines contain a small portion of alcohol. Its use in counteracting the effects of snake-bite are well known.

Effects. — *The General Effects of Alcohol* are insidious, serious, and saddening. "The evil that men do lives after them," is only too true in the general effects of the use of alcoholic drinks. Beer, wine, liquors and whatever other names the different beverages may bear that are used by mankind on account of the effects which the smaller or greater percentage of alcohol they contain may exert, are known for their general effects upon the human system as well as for the certain special effects which we shall describe hereafter. Most

people use them as stimulants, some as medicine, and some — the unfortunate victims of a slavish desire — as a means of reaching an early grave.

The Special Effects of Alcohol are both of a *stimulant* and a *narcotic*. As a stimulant, it excites the brain and nerves, increases the circulation of the blood, and intoxicates, while as a narcotic it blunts the powers of the brain and nerves, and produces stupor, and finally, death. Since alcohol contains no nitrogen, it lacks one of the chief elements of food, and consequently will not sustain life. "Alcohol has no iron nor salts for the blood; no gluten, phosphorus, nor lime for the bones; and no albumen, or substance which is the basis of every living organism." — *Dr. Lees.* Hence, it cannot be termed a food. Tests in the army, navy and Arctic exploration* have definitely proven the above position.

Neither will alcohol allay thirst, and for the follow-

* The Arctic explorer, Dr. Rae, states that he found entire avoidance of alcohol necessary in the far North. The moment a man had swallowed a drink of spirits, it was certain that his day's work was nearly at an end. "It was absolutely necessary that the rule of total abstinence should be rigidly enforced, if we would accomplish our day's task. Any use of liquor, as a beverage, when we had work on hand, in that terrific cold, was out of the question."

ing reasons: Alcohol has great attraction for water, and when swallowed draws the water to itself, thus depriving the tissues of the body of that most necessary inorganic food. Again, alcohol causes a rush of blood to the skin, when a sensation of heat is felt upon the surface of the body. However, the sensation of heat is like beauty, "only skin deep," as the heat of the system has really been diminished rather than increased, because when the blood is upon the surface, it parts with its heat more readily. The deception is similar to the case of the ostrich, which imagines himself concealed when only his head is hidden.

Let us discuss this subject as to the effects upon the individual organs and parts of the human system.

(1.) *On the Heart.*—The reason why small quantities of alcohol which are greatly diluted with water stimulate the system, is due to the fact that the alcohol enters the circulation, permeates the body and is burnt up or oxidized within the system, yielding, as a result of this combustion, heat and vital force to the tissues of the body. Given the number of heartbeats at 100,000 per day of twenty-four hours, an ounce of pure alcohol will raise this to 104,000, which increased beating overworks the heart. Since, then, the circulation is stimulated, it follows

that the action of the heart is invigorated; the structural part of this organ, however, suffers no change. Larger doses of "stimulants," however, exert a depressing influence upon the heart, rendering it flabby, dilated, and sometimes fatty, so as to reduce its action; they lower the temperature of the body and generally retard the action of the cells. In the language of a medical author —

"The agreeable excitement at first caused by such doses of alcohol is succeeded by a reaction, characterized by lassitude and drowsiness, the latter condition usually lasting longer than the previous one of exhilaration."

In many diseases it is desirable to animate the circulatory system to greater action; this is especially the case with fever patients; they can stand considerable quantities of alcohol without intoxicating effects; and as alcohol lowers the temperature of the body, the fever-heat is lowered also, owing to the use of alcohol, and thereby improves the condition of the patient.

Then the effects of alcohol upon the heart may be summed up in the following statements: —

(*a.*) It causes a softening of the muscles of the heart and a fatty degeneration, thus clogging the workings of this vital organ.

(*b.*) It overworks the heart.

(*c.*) Oftentimes it renders the heart weak and flabby.

(*d.*) It causes an enlargement, or dilation of its parts.

(*e.*) There is a consequent effect of drowsiness and lassitude.

(*f.*) Its general effect upon the heart is to destroy its strength and usefulness.

(2.) *On the Lungs.* — Persons who are addicted to excessive drinking, and especially those "chronic" drinkers who are predisposed to lung troubles, are subject to pneumonia and to consumption. In these disorders, the trouble is aggravated by a diseased condition of the blood, brought about by the use of alcohol. As the diseased blood comes to the capillaries of the lungs, this impairs the lungs themselves, which adds to the impurity of the circulating fluid. It also tends to paralyze the capillaries of the lungs, while it gives the breath a most disagreeable odor. Hence, it is learned that alcohol has the following effects upon the lungs: —

(*a.*) It makes the blood impure, thus increasing the work of the lungs.

(*b.*) It paralyzes the blood-vessels.

(*c.*) It weakens the various lung tissues.

(*d.*) Alcohol vitiates the breath.

(3.) *On the Stomach.*—The immoderate use of alcohol may produce chronic inflammation, congestion or catarrh of the stomach and the duodenum. The inner coat of the stomach is greatly changed by the excessive use of alcohol, and loses its capacity for secretion and absorption.

To appreciate the effect of alcohol upon the mucous lining of the stomach, take a mouthful of the liquor into your mouth. Since it burns your mouth, how much more so the very delicate stomach lining. In a natural state, the stomach lining is a beautiful pink, but alcohol destroys this condition and covers it with ulcers and sores. Read what Dr. Beaumont learned of these effects by experiments upon Alexis St. Martin: "The free use of ardent spirits, wine, beer, or any of the intoxicating liquors, when continued for some days constantly, produced a state of inflammation and ulceration in the lining membrane, and change in the gastric juice." Not only does it harden the tissue of the stomach lining, destroy some of the little glands, and impair the others, but it affects the mucous, making it thick, and precipitates the pepsin, which delays digestion. As a result of the quickened action of the stomach, the effect upon

its tissue and fluids, and the derangement of its organs, digestion in the stomach is materially impaired and the nutrition of the body greatly weakened and lessened, which will finally lead to a total collapse of the digestive system. Hence, to recapitulate:—

(*a.*) Alcohol produces chronic inflammation of the stomach.

(*b.*) Injures the mucous lining by hardening the tissue.

(*c.*) It destroys some of the small glands and impairs the others.

(*d.*) It precipitates the pepsin of the gastric juice, thus retarding digestion.

(*e.*) It thickens the mucous of the stomach.

(*f.*) The action of the stomach is at first quickened by the presence of alcohol, and then retarded.

(4.) *On the Liver.*—A commonly occurring disease of the liver, known as *cirrhosis* of the liver (or gin-drinker's liver), in which this organ becomes hardened and shrunken, arises from an abuse of alcoholic drinks, more especially of spirits undiluted with water, which reach the liver through the blood by the portal vein. Most cases of this kind, when once established, terminate in death. Through the

effects of alcohol, the vessels of the liver are over-filled, which affects the liver end of digestion by producing a fatty enlargement. This enlargement is followed by a lessening of the cells which produce the bile, and thus interferes with the proper passage of the blood through this necessary and important organ. Again the tissue of the liver may be greatly enlarged by the presence of alcohol in that organ. It has been recorded of a drunkard that his liver was found to weigh fifty pounds, while a healthy one weighs only a few pounds. Again, alcohol stimulates the liver to over-action, which results later in its inability to secrete the proper amount of bile.

In substance, then, the effects of alcohol upon the liver may be:—

(*a*.) It produces a hardened condition of its tissue.

(*b*.) It enlarges the organ.

(*c*.) It compresses and lessens the cells for producing bile.

(*d*.) It stimulates the liver to over-action, thus reducing the bile supply.

(*e*.) It weakens and destroys the usefulness of this organ of digestion.

(5.) *On the Blood and Blood-vessels.*—Whatever impairs the functions of the stomach is certain also to

impair the proper condition of the blood and the nutrition of the body; so that an habitual excess of alcohol cannot but deteriorate the "life-giving" fluid. A too frequent use of alcohol tends to change the coats of the blood-vessels by unduly dilating them, as their muscles become weakened. Both changes combined — that of the blood and the vessels that circulate it through the body — together with the injurious influence which large doses of alcohol have upon the nerves, have a baneful effect upon the entire system. It is interesting to know how alcohol reaches the blood. From the stomach, it is immediately absorbed into the blood, while some of it passes on into the intestines to pass to the blood by the lacteals. When in the blood, alcohol tends both to thin and coagulate the blood, owing to the amount of the drug present. It has a deadening effect upon the corpuscles, destroying their power to carry oxygen or carbonic acid gas; hence it prevents combustion, which prevents the purification that ought to take place. This effect subsequently impoverishes the blood, producing skin disorders of a dangerous nature. The fact of alcohol's hastening the circulation was discussed in the topic — *On the Heart.*

This topic will be concluded with the statement that alcohol exercises a paralyzing influence upon the nerves controlling the muscular fibres of the arteries.

Therefore, the effects of alcohol upon the blood and blood-vessels are:—

(*a.*) It thins or coagulates the blood, according to the amount of alcohol.

(*b.*) It hastens the circulation, thus weakening it.

(*c.*) It prevents combustion.

(*d.*) It impairs and destroys the corpuscles, thus affecting their power of transporting oxygen and carbonic acid gas.

(*e.*) Alcohol weakens the arterial muscles by affecting the nerves governing them.

(*f.*) It produces skin disorders of dangerous kinds by vitiating the blood.

(6.) *On the Brain and Nervous System.*—A large amount of alcohol acts on the nerves and nerve centers as a poison. In the latter stage of drunkenness or debauch it may cause insensibility to such a degree as to produce death. We quote from a learned writer on the subject: "In slight cases of intoxication prolonged drowsiness may be the chief symptom, but in the more severe forms the patient is quite insensible; the power of motion is in complete abeyance; the breathing is loud and deep; the face is usually pale; the pupils are generally dilated; the

pulse is slow and labored; the skin feels cold and clammy; the temperature is low."

By its hastening influence upon the blood-vessels of the brain, these are so enlarged that they produce a compression, which results in epilepsy or apoplexy. The presence of alcohol in the brain will harden the tissue of that organ, which is mainly albumen. As a test of this, pour alcohol over the white of an egg, and notice the effect in a short time. The albumen coagulates. Why not the brain substance, then? Alcohol seems to seek the brain, as more of it is found there than in any other organ. This presence of alcohol certainly paralyzes the nerve-centers of this vital organ, leaving an enfeebled reason, a lessened and weakened will-power, with a consequent loss of self-control, all of which lead to temporary, if not permanent, insanity. Alcohol destroys the nerve fibre of the brain; if not, it diminishes its sensibility and unfits it for proper use.

The effect of alcohol upon the morals is awful. "All delicacy, courtesy and self-respect are gone; the sense of justice and of right is faint or quite extinct; there is no vice into which the victim of drunkenness does not easily slide, and no crime from which he can be expected to refrain. Between this condition and insanity there is but a single step."

"If by reducing the balancing power of the vessels

which regulate the supply of the blood to my brain, I permit a more rapid current of blood to feed my brain, I may for a time think more rapidly, and express myself with more apparent energy. It is clear, however, that under such circumstances I do but exhaust more quickly, require to be wound up more frequently, and wear out more speedily." — *Dr. Richardson.*

There are times, when men have seemed to be brighter and more brilliant when under the influence of liquor; but it is an abnormal condition.* The various effects of alcohol upon the brain and nerves are:—

(*a.*) It causes apoplexy or epilepsy by confusing the brain.

(*b.*) It weakens the will and deadens the feelings.

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* In the normal state of a man's mind, all the faculties, the imagination, the judgment, the memory, the association of ideas, are regulated by another superior faculty, viz., the attention. The attention of the will is the man himself; it is the *ego* which, being in the full possession of the resources of which it disposes, takes them where it will, when it will, to do whatever it pleases. Now in drunkenness, even at the very beginning, the will and the attention have disappeared. Nothing is left but the imagination and the memory, which, left to themselves, without regulation and without guides, produce the most irrational results." — *Charles Richet.*

(*c.*) It hardens the brain tissue, producing dullness, insensibility and insanity.

(*d.*) It destroys the nerve fibre of the brain.

(*e.*) It temporarily stimulates and finally depresses this organ.

(*f.*) It will at last destroy man, body and soul.

2. WINE, RUM, BRANDY, ARRACK AND OTHER SPIRITUOUS LIQUORS.

Stimulants.— *Wine* is the fermented juice of the grape. One thousand parts of it contain, as a rule, about 900 parts of water, 80 parts of alcohol, and 20 parts of various bodies, such as acids and ethers. The Chinese forbade the use of wine and the cultivation of the grape.

Wines containing a large portion of carbonic acid gas are called "sparkling" wines; such as contain a great deal of "acid" are called "sour" wines; those containing much free sugar, "sweet" wines, and those containing a large quantity of alcohol, "strong" or "heavy" wines.

Red wines contain from about 10 to 15 per cent of alcohol, which means that 100 volumes of such wines contain from 10 to 15 like volumes of alcohol. White wines contain less.

The home-made wines from currants, elderberries, gooseberries, blackberries etc., contain a very small per cent of alcohol.

Rum is the product of the distillation of fermented sugar cane, and is fully one-half alcohol.

Cider is make from apples, and contains about 7 per cent alcohol.

Brandy or *Cognac* is a result of the distillation of strong wines, and has as much alcohol as rum.

Arrack is obtained by distilling rice or palm juice and is much used as a drink by the Africans.

Whisky is a product of the distillation of wheat, rye or corn.

Liquors, in general, are highly flavored liquids containing a large percentage of alcohol mixed with large quantities of sugar.

Beer, *Ale*, and *Porter* contain less alcohol than wine; generally not over five per cent, and are made from grain.

Coffee and Tea are mild stimulants, yet they should not be taken in strong doses, nor in large quantities. Their effect seems to be to assist digestion; they are therefore generally taken after meals.

But their *intemperate* use causes indigestion, nervousness, and other troubles.

Chocolate and Cocoa are not so stimulating as coffee and tea, but are much more nutritious.

3. TOBACCO.

History and Properties.— Tobacco is a native of America, from where it was taken to Europe.

This plant, of the *genus nicotiana*, is a broad-leaved annual, growing five or six feet high, and cultivated as far north as Mason and Dixon's line.

The leaves are cut, dried, and cured, when they are made into various forms for use, too well known to need description. The leaves have a sharp, bitter taste, and are of a poisonous, narcotic nature, which is due to a volatile alkaloid called *nicotine*, from *Jean Nicot*, a Frenchman who first introduced it into France.

Uses and Effects.— Nicotine is a dark-colored, deadly poison, derived from tobacco, a few drops being sufficient to kill an animal. Its effects upon young people are especially serious, producing nausea, vomiting, vertigo, weakness, heartburn, convulsions, and unsteady nerves. Its use, at first, produces a mild stupor, which is followed by restlessness and muscular weakness. Without doubt, it deadens

the sensibilities and impairs the brain power. While it affects in a no less degree the senses of hearing, seeing, smelling, and tasting, its filthy, disgusting appearances and effects, when chewed, are very offensive to the sight. Smoke, especially from an old pipe, will cause headache and even fainting, and general derangement of the stomach.

Its effects upon the morals are daily apparent when persons insist upon smoking in crowded railroad waiting-rooms, cars, and street cars, totally oblivious either to the presence, comfort, or health of ladies. Many legislatures are now framing laws to prohibit expectorating in public places and conveyances, which is chiefly due to tobacco users.

The Use of Cigarettes seems to be more prevalent among the young, and there are, aside from this fact, two dangers in this habit: The smoke is inhaled and then exhaled through the nostrils, burning, searing, discoloring, poisoning the delicate membranes of the lungs. In short, it is turning this most delicate organ into a smoke-house of the vilest sort. Again, the cigarettes generally are adulterated with opium — a drug of most dangerous and poisonous character. Now, the physical effects of cigarette-smoking are seen in the pale, sallow complexion, yellow fingers, and trembling limbs, while its effects eventually are

noticed in loss of will-power, sense of morality, power of application, with a general unfitness for mental application and terminating in forms of insanity and suicide. There is an organization of ladies, widely known in this country, whose efforts in putting down the use of tobacco and alcohol ought to be seconded most heartily by every well-meaning citizen.

But the cases of "tobacco poisoning" by means of nicotine are very rare. The mischief done by smoking cigarettes or by the excessive use of tobacco is of slow growth and effect, but nevertheless sure. To one not used to smoking, the effects of a small dose of tobacco are well known. The effects from an excessive use of it are: A tendency to lower the general health; to decrease the digestive capacity; and to weaken or irritate the nerves and brain. While the *temperate* use of tobacco apparently works no harm in adults, this does not argue that it is beneficial to them; and its use by the young should at all times be condemned, because to them even a mild use of it is hurtful to the highest degree.

4. NARCOTICS.

Narcotics Are Drugs which induce sleep or insensibility. The principal narcotics in use are (1)

opium and *morphium*, or *morphia*, (2) *chloroform*, (3) *sulphuric ether*, (4) *chloral*, (5) *cocoaine*, (6) *bromide of potassium*, (7) *belladonna*, (8) *digitalis*, (9) *alcohol.*

In smaller doses these substances cause sleep; in larger doses, insensibility, which may terminate fatally.

(1) *Opium.** — Laudanum and morphium, paregoric and Dover's powders — these substances are the most effective and reliable narcotics. Laudanum is a preparation of opium, which is the thickened juice of the poppy-plant found in Asia. Morphium or morphia, is the most valuable part of opium; it is the morphium in opium which renders opium effec-

*The opium-eater loses none of his moral sensibilities or aspirations; he wishes and longs earnestly as ever to realize what he believes possibilities, and feels to be exacted by duty; but his intellectual apprehensions of what is possible infinitely outruns his power, not of execution only, but even the power to attempt. He lies under the weight of incubus and nightmare; he lies in sight of all that he would fain perform, just as a man forcibly confined to his bed by the mortal languor of a relaxing disease, who is compelled to witness injury and outrage offered to some object of his tenderest love; he curses the spells which chain him down from motion; he would lay down his life if he might but get up and walk; but he is powerless as an infant, and cannot even attempt to rise."— *De Quincey's Confessions of an Opium Eater.*

tive as a narcotic. This class of narcotics may relieve pain even without causing sleep. Lettuce and dandelions have similar but far milder effect in causing sleep. Opium is administered especially in typhus fever and other disorders, when delirium and loss of sleep may become dangerous to life. But opium also acts as a drawback, as it tends to disturb the stomach. And the habit of "eating" opium is a terrible practice, particularly to the young, affecting the stomach, muscles, and nerves. Yet the great Boerhaave called opium "the finger of God."

(2) *Chloroform.* — This powerful anæsthetic, a product of alcohol, was first introduced by Simpson, of Boston, 1847. It is a very convenient remedy to annul pain, but a very dangerous one, as some persons are particularly likely to be affected by it in the heart. It is especially useful in surgical operations.

(3) *Sulphuric Ether.*— This is a colorless liquid, the vapors of which, when inhaled, blunt the senses, especially the sense of pain, so that even severe pains are no longer felt, and short operations may be performed during the time inhalation goes on. When the inhaling process ceases, sensibility returns almost immediately. It is a much safer narcotic than opium or chloroform.

(4) *Chloral.*— This substance, also derived from

alcohol, is most likely to affect the heart, and is a valuable remedy for simple sleeplessness. Yet, its continued use may become a dangerous habit, and a physician should be consulted in its use.

(5) *Cocoaine.*— This is an alkaloid obtained from the leaves of *coca.* This drug has but recently been introduced into medicine, and has become very prominent on account of its being the strongest *local* anæsthetic known; that is, it deadens the sensibility of a single organ without affecting the others; for example, if applied to the eye it produces complete insensibility of the cornea and conjunctiva, which permits operations to be performed on this delicate organ without the aid of chloroform or ether.

Another remarkable property of this substance is its anæsthetic effect upon the mucous membrane. Like all narcotics it should be taken or administered with great caution; and the effects of its abuse are terrible.

(6) *Bromide of Potassium* is usually administered to restore brain and nerves from the fatigue produced by overwork. It, too, however, has, like all narcotics, its disagreeable features, one of which is its weakening influence on the muscles.

(7) *Belladonna*, and (8), *Digitalis.*— Both are remedies for strengthening the heart and the arteries,

and preventing too free a flow of blood to the brain. They should be used with caution and under the direction of medical advice.

(9) *Hasheesh*, the juice of Indian hemp, is said to be used by millions of the inhabitants of Asia. It is not much known in the western countries. In the East the excitement caused by its use takes the form of furious madness, leading its victim to commit acts of violence and murder. Hence the term "hasheeshers" in our language has come to be synonymous with assassins — *Hutchison.*

Of all the ills that suffering man endures,
The largest fraction liberal Nature cures,
Of those remaining, 'tis the smallest part
Yields to the efforts of judicious Art;
But simple kindness, kneeling by the bed
To shift the pillow for the sick man's head,
Give the fresh draught to cool the lips that burn,
Fan the hot brow, the weary frame to turn,—
Kindness, untutored by our grave M. D.'s,
But nature's graduate, when she schools to please,
Wins back more sufferers with her voice and smile
Than all the trumpery in the druggist's pile.

— Dr. Holmes, "*The Morning Visit.*"

REVIEW QUESTIONS.

1. How is it known that intemperance is hereditary? What does Dr. Allen say about spirits?

2. Quote Pope's favorite stanza. Explain the last line.

3. Tell what is said about the influence of alcohol upon humanity. What does Brand say?

4. Give the derivation of the word alcohol. When was the drug first used?

5. What was alchemy? What is chemistry?

6. Who was Brown-Sequard? Dr. Koch?

7. Who brought alcohol into Europe? How has it spread?

8. Describe alcohol. How does it produce the sensation of cold?

9. State something of its chemical composition. How is it related to the sugars?

10. Give an experiment showing how the presence of alcohol is made evident.

11. Give several of its uses in the arts. In medicine. In other sciences.

12. State several general effects of alcohol. Describe *delirium tremens*.

13. Is alcohol a food? What is the testimony of an Arctic explorer?

14. How does it produce thirst? Why does the drinker imagine he is warm when he is not?

15. Explain fully the action of alcohol upon the heart. How does it increase the number of heart-beats? Sum up its effects.

16. Likewise, give its effects upon the lungs.

17. Give its effects upon the stomach. How does alcohol first reach the blood? What were the results of Dr. Beaumont's experiments upon St. Martin? State its effects upon the different fluids, membranes, etc., in the stomach. Give the effects in order.

18. In the same manner, state its effects upon the liver. What disease of this organ is produced by alcohol?

19. How does it affect the blood and the blood-vessels? Give the effects in detail.

20. State its effects upon the brain tissue. Upon the action of the brain. What brain diseases are produced by it? How does it affect the moral sensibilities? Tell what Charles Richet says about its effect upon the faculties.

21. Name several liquors, containing considerable alcohol. Which are made from grains? Which from fruits?

22. Name several kinds of wines. Do home-made wines contain much alcohol?

23. How should coffee and tea be used? What relation do chocolate and cocoa bear to foods?

24. Give the history of tobacco. Tell the little incident that happened to Sir Walter Raleigh.

25. Give the properties of "the weed." Where is tobacco cultivated? How did the name originate?

26. What is the active principle in tobacco? From whom named?

27. Give the effects of tobacco. Why are its users so careless of the comfort of others?

28. What is the especial danger in cigarettes? Are they widely used? In what respect do their use and composition differ from those of tobacco?

29. What is a narcotic? Name several. What is the different results according to the size of doses?

30. Name the forms of opium. Where is the native home of this drug? What are its effects?

BLACKBOARD OUTLINE.

ALCOHOL.—STIMULANTS—NARCOTICS—THEIR EFFECTS.

1. **Alcohol.**
   - History and Properties.
   - Manufacture.
   - Uses — Effects.
     - General.
       - Mind,
       - Body.
     - Specific.
       - On the Heart,
       - On the Lungs,
       - On the Stomach,
       - On the Liver,
       - On the Blood and Blood-vessels,
       - On the Brain and Nervous System.

2. **Wine, Rum, Brandy, Arrack, and Other Spirituous Liquors.**
   - Their Properties and Uses.

3. **Tobacco.**
   - History and Properties.
   - Production.
   - Uses and Effects.

4. **Narcotics.**
   - Kinds, Properties, Uses and Effects.
     - Opium,
     - Chloroform,
     - Sulphuric Ether,
     - Chloral,
     - Cocaine,
     - Bromide of Potassium,
     - Belladonna,
     - Digitalis,
     - Hasheesh.

X.

EMERGENCIES.

The readiness is all.— Hamlet.

X. Emergencies.

1. DROWNING.

Marshall Hall's "Ready Method" of treatment in asphyxia from drowning, chloroform, coal-gas, etc.

1st. Treat the patient *instantly on the spot*, in the *open air*, freely exposing the face, neck, and chest to the breeze, except in severe weather.

2d. In order *to clear the throat*, place the patient gently on the face, with one wrist under the forehead, that all fluid, and the tongue itself, may fall forward and leave the entrance into the windpipe free.

3d. *To excite respiration*, turn the patient slightly on his side, and apply some irritating or stimulating agent to the nostrils, as *veratrine*, *dilute ammonia*, etc.

4th. Make the face warm by brisk friction; then dash cold water upon it.

5th. If not successful, lose no time; but, *to imi-*

tate respiration, place the patient on his face, and turn the body gently, but completely *on the side, and a little beyond;* then again on the face, and so on, alternately. Repeat these movements deliberately and perseveringly, *fifteen times only* in a minute. (When the patient lies on the thorax, this cavity is *compressed* by the weight of the body, and *ex*piration takes place. When he is turned on the side, this pressure is removed, and *in*spiration occurs.)

6th. When the prone position is resumed, make a uniform and efficient pressure *along the spine*, removing the pressure immediately, before rotation on the side. (The pressure augments the *ex*piration, the rotation commences *in*spiration.) Continue these measures.

7th. Rub the limbs *upward* with *firm pressure* and with *energy*. (The object being to aid the return of venous blood to the heart.)

8th. Substitute for the patient's wet clothing, if possible, such other covering as can be instantly procured, each bystander supplying a coat or cloak, etc. Meantime, and from time to time, *to excite inspiration*, let the surface of the body be *slapped* briskly with the hand.

9th. Rub the body briskly until it is dry and

warm, then dash *cold* water upon it, and repeat the rubbing.

Avoid the immediate removal of the patient, as it involves a *dangerous loss of time;* also, the use of bellows, or any *forcing* instrument; also, the *warm bath*, and *all rough treatment.*

2. CUTS.

Hemorrhage from Divided Arteries should be Arrested, otherwise the heart soon ceases its action, and the person faints. If a large artery is wounded, every beat of the pulse throws out the blood in jerks. Until surgical help can be summoned, the flow of the blood may be stopped either by compressing the vessel between the wound and the heart, or by compressing the end of the artery next the heart in the wound.

After compression as described and illustrated, take a square piece of cloth, or handkerchief, twist it cornerwise, and tie a hard knot in the middle. Place the knot over the artery between the wound and the heart, carry the ends around the limb and tie loosely. Place a stick under the handkerchief near the last tie, and twist till the fingers can be removed from the compression without a return of the bleeding. When an artery in a

limb be cut, elevate the limb as far as possible, till the bleeding ceases."

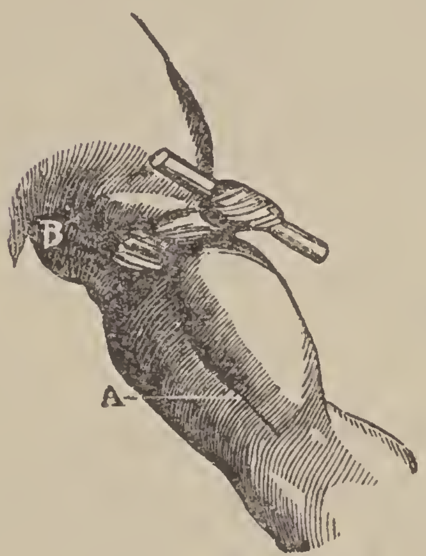

FIG. 69.

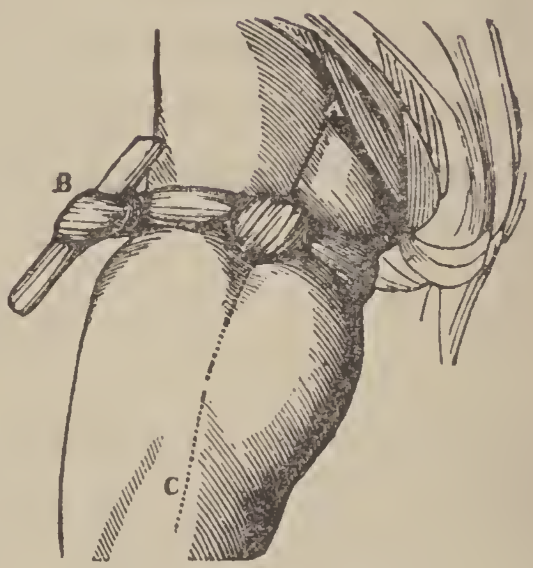

FIG. 70.

FIG. 69. The method of applying the knotted handkerchief, to compress a divided artery. *A, B,* Track of the brachial artery.

FIG. 70. *A, C,* The track of the femoral artery; the compress applied near the groin.

3. BURNS.

If the clothes catch fire, wrap the person quickly in a coat, mat, shawl, carpet, or any other woolen article, to extinguish the flame, and lay him down at once. Pour on plenty of water to cool the burning clothing. The party should then be carried to a warm room and laid on a table or carpeted floor. Remove the clothing carefully with scissors or knife.

Do whatever can be done to keep the air from the burns. Soft cloths wet with sweet oil, applied to the parts, is a good accessory.

4. CONVULSIONS.

These may be trivial or grave. If it is a young woman, the attack is probably hysterical and, as a rule, not dangerous, and a sprinkle of cold water will bring relief. If the patient struggles with regularity of movement, and there is bloody froth on the lips, it is a case of epilepsy, and requires a physician's attendance. Meanwhile protect the head from injury by putting a pillow or some soft article beneath it; a cork introduced between the teeth will prevent the biting of the tongue. Prevent the patient from falling or injuring himself, but do not attempt to forcibly hold him quiet.

In children, apply cloths dipped in water to the head; disturb the child as little as possible; do not use a warm bath until directed by the doctor.

XI.

APPENDIX.

When all has been said there is still more to be added.

—Morgan.

IX. Appendix.

SKELETON — Classification of Bones.

Classes of Bones as to Shape :—

1. Long Cylindrical:
   Femur,
   Humerus,
   &c.
2. Short Cylindrical:
   Phalanges,
   Carpals,
   &c.
3. Flat:
   Scapula,
   Sternum,
   &c.
4. Irregular:
   Sphenoid,
   Sacrum,
   &c.

CIRCULATION.

Portal Circalation.— There is a part of the systemic circulation called by some the *portal circulation*. It is that part which conveys the blood into and from the liver, called by this name from the Latin word, *porta*, a gate, because the blood-vessel enters the liver by a kind of gateway. The veins from the stomach, spleen,

pancreas, and intestines unite in forming one large trunk about three inches long, called the *portal vein*. This enters the liver where its subdivisions are well distributed. These subdivisions then come together into one vessel known as the *hepatic vein*.

The food which the capillaries absorb directly through the walls of the stomach and intestines, is carried into the liver. In the liver a change goes on but no one positively knows what it is. Sugar seems to be changed to a kind of starch and is stored in the liver for future use. When needed, is changed back to sugar and taken up by the circulation. It will be remembered that there are two ways by which the nutriment of the food reaches the blood — one through the walls of the alimentary canal into the lacteals thence into the thoracic duct which empties into the vena cava, the other through the walls of the alimentary canal directly into the capillaries into the blood. The latter is through the portal circulation. It has been thought that the nourishment from sugars and starches, etc., reaches its destination by way of the portal circulation, while that from fats passes through the lacteals.

DISSECTION.

Heart.— No amount of description will give a full, correct understanding of the heart. This is true also of many other organs of the body. Get the actual thing and cut it up. Secure the heart of some animal, as the ox, sheep, hog, or any other of the mammals. Wash clean, then fill with water to observe its shape. Now empty and cut as follows: Cut off the auricles just above their lower margins. Observe the appearance of the valves from above. Then cut vertically through from right to left. Wash again so as to get the best possible view of the structure. Notice valves, walls, cavities, etc. Cut out through the arteries to see their structure and valves.

Lungs.— Get the lungs of a sheep, or of some other animal; the sheep is best. See that lungs, trachea, and larynx are all intact. Wash thoroughly. They must be fresh from the animal and not allowed to dry. When well cleaned place the mouth at the top of the larynx and blow with force so as to fill the lungs with air. Now compress the lungs. Repeat this experiment—observing the action of the lungs. To examine the structure cut transversely through larynx from front to back, and through trachea from right to left. In the lung itself split the bronchial tubes, running the knife out through the lung substance. Wash at each cutting.

These examples are suggestions. The energetic student and the wide awake teacher will find and use other parts.

POISONING,

When a person is discovered to have swallowed poison, unless vomiting has already occurred, empty the stomach by an emetic that can be most readily and quickly obtained, and is prompt and energetic, but safe in its action; for this purpose, there is, perhaps, nothing better than a large teaspoonful of ground mustard in a tumblerful of warm water. If the mustard is not at hand give 2 or 3 teaspoonfuls of powdered alum in syrup or molasses, and give freely of warm water to drink; or give 20 gr. of sulphate of zinc (white vitriol), or of ipecac, in a large cup of warm water and tickle the throat with the finger, or with the feather end of a quill; copious draughts of warm water or mucilaginous fluid should be given to keep vomiting up until the poisonous substances have been thoroughly evacuated, and then suitable antidotes should be given. If vomiting cannot be produced, the stomach pump should be used.

GLOSSARY.

CONTAINING THE ANATOMICAL AND PHYSIOLOGICAL MEANING OF CERTAIN TERMS.

Ab-do'men. The largest cavity of the body; below the diaphragm and above the pelvis, containing the stomach, intestines, liver, spleen, etc.

Ac'id. A substance generally sour to the taste, which changes vegetable blue colors to red, and combines with bases to form salts.

Adipose'. Fat, or fatty.

Albu'men. A substance like the white of an egg, coagulating by heat.

Alcohol. A result of the decomposition of sugar.

Al'i-ment. Nourishment; food.

Al-i-ment'ary Ca-nal. A tube passing through the body, beginning with the mouth, piercing the diaphragm, and terminating with the rectum, by which nourishment is taken into the body, digested, and indigestibles execreted.

Aor'ta. The great artery arising from the upper and the back part of the left ventricle of the heart; the common trunk of the arteries of the body.

Appara'tus (Physiol.). A system of organs concerned in some special function of the animal body.

Arrack. Product of the distillation of rice or palm-juice.

Ar'tery. Any branch of the aorta conveying blood in the direction from the heart to all parts of the body.

As-sim-i-la'tion. The conversion of food into the substance of organized beings.

Au'ricle. The external ear. Hence one of the two venous chambers of the heart, resembling the external ear.

Beer. A fermented liquid made from any malted grain, with the addition of hops and other substances.

Bi'ceps. Two-headed. A muscle attached to the shoulder-bone, connecting it with one of the bones of the fore-arm.

Bicus'pid. A molar tooth having two points.

Brandy. A result of the distillation of strong wines.

Bronch'us. The windpipe, or trachea. The *bronchi*, or *bronchia*, now mean the two tubes which arise from the bifurcation of the trachea, and carry air into the lungs.

Cognac. A result of the distillation of strong wines.

Cam'era-obscu'ra. An instrument used in a darkened room to throw images of external objects upon a surface.

Ca-nine'. Applied to teeth, it means the pointed tooth next to the incisor. It is often quite long.

Cap'-il-la-ries. A net-work of minute blood-vessels, connecting the termination of the arteries with the termination of the veins.

Car'di-ac. From the Greek *kardia*, the heart.

Carniv'orous. Flesh-eating. *Carnivore*, a carnivorous animal.

Car'ti-lage, or gristle. A dense, firm substance of less hard tissue than bones.

Cell. A small, distinct, spheroidal mass of protoplasm or living material.

Cer-e-bel'lum. The little brain, beneath the cerebrum.

Cer'e-brum. The brain proper, occupying the entire upper portion of the skull.

Cho'roid. A coat containing a great many blood-vessels, lining the interior surface of the sclerotic coat of the eye.

Chyle. A milky fluid formed in the process of digestion by the action of the pancreatic juice and the bile on the chyme in the duodenum.

Chyme. A pulp formed by the action of the stomach on the food.

Cil'i-ary Processes. The minute radiating ridges formed around the iris by the anterior portion of the choroid.

Clav'i-cle. The collar bone.

Coch'lea. A cavity of the ear resembling a spiral shell.

Cohe'rence. The act or state of cohering.

Co'lon. That portion of the large intestine extending from the cæcum to the rectum.

Connec'tive tissue. The connective medium by which the different parts of the body are held together. It passes from the dermis between all the other organs, ensheathing the muscles, coating the bones and cartilages, and ultimately entering into the mucous membranes.

Contrac'tile. Having the power of contraction.

Corpus'cle. Minute body or particle of matter.

Cu'ti-cle. The superficial layer of the skin. The same as *epidermis.*

Cutis. The deeper portion of the skin. The same as *dermis.*

Degluti'tion. The act, or power, of swallowing food.

Delirium Tremens. Usually the result of continuous intoxication.

Dentine. The principal constituent of a tooth.

Deriva'tion. Transmission of anything from its source.

Dermis. The same as *cutis.* (See this.)

Diaphragm. The muscular partition separating the chest from the abdomen, and assisting respiration.

Dias'tōle. A dilatation of the heart and arteries; opposed to *systole.*

Digestibility. The quality of being digestible.

Dilatation. Expansion.

Duodenum. The first of the small intestines; is about as long as the breadth of twelve fingers.

Enam'el. The hard exterior surface of the teeth.

Epidermis. The same as cuticle. (See this.)

Epiglot'tis. A cover on the aperture of the windpipe.

Eu-sta'chi-an Tube. A tube extending from the inner side of the tympanum, opening at the back of the nostrils.

Fetor. A strong, offensive smell.

Fi'brine or *fibrin.* A white, tough, fibrous substance, obtained from coagulated blood.

Func'tion. Performance, office work, action.

Gan'gli-on, pl. *ganglia.* A mass of nerve-cells, forming a center from which nervous fibres radiate.

Gas'tric. Belonging to the stomach.

Glot'tis. Aperture at the top of the larynx.

Hem'or-rhage. Loss of blood; bleeding.

Herbiv'orous. Feeding of plants. *Herbivore*, herb-eating animal.

Hy'gi-ene. The knowledge of the preservation of health.

Il'eo-jeju'num. The part of the small intestine immediately succeeding the duodenum.

Incis'ors. The four front teeth of both jaws.

Innervaton. The function of the nervous system.

Inorgan'ic. Destitute of organs or animation.

In-sal-i-va'-tion. The mixing of food with saliva.

I'ris. A membrane with an aperture in the center, stretched vertically across the eye, and separating the anterior from the posterior chamber. It gives the eye its color.

Lab'y-rinth. The internal ear.

Lac'te-al. A lymphatic vessel of the intestinal canal. (See *Lymphatic.*)

Lar'ynx. Cavity at the top of the trachea, the organ of voice.

Lever. A stiff bar or rod, which turns on, or is supported in, a fixed point.

Lig'a-ment. A strong fibrous material, uniting bones or other solid parts together.

Liquors. Highly flavored liquids containing large quantities of alcohol and sugar.

Lymphat'ic. Vessel conveying a colorless, watery fluid, called *lymph*, to the thoracic duct.

Mas-ti-ca'tion. The act of chewing.

Me-dul'la Ob-lon-ga'ta. "The oblong marrow." Portion of the nervous cord within the skull nearest to the spinal cord.

Mem'brane. A thin layer of tissue, serving to separate, cover or envelop other organs.

Mo'lar. A grinding tooth.

Mo'tor. Giving motion.

Mu'cous Mem'brane, or Mucous Coat. The continuation of the skin, in apertures and interior cavities: that is, the lining of the internal cavities.

Mu'cus. A more or less tenacious fluid.

Narcotics. Remedies inducing sleep or insensibility.

Nutri'tion. The conversion of food into nutriment. Sometimes used to comprise digestion, absorption, respiration, circulation and assimilation.

Œ-soph'a-gus. The tube which extends from the interior portion of the pharynx to the stomach; the gullet.

Organ'ic. Having organs, animation; or, pertaining to organs. Hence, *organism* = an organic being.

Ossifica'tion. The formation of bone.

Pal'ate. The roof of the mouth.

Pancreas, or "*sweet-bread.*" A gland of the abdomen, under and behind the stomach, at the right of the spleen.

Pel'vis. Two separate bones to which the legs are attached, and which bound the abdomen below.

Phys-i-ol'o-gy. The science of the functions of animals and vegetables. Human physiology is the science which treats of the functions of the human body and the manner in which they are brought about.

Proc'ess. Eminence of a bone; a portion prolonged beyond others with which it is connected.

Pul'mo-na-ry. Pertaining to or affecting the lungs.

Py-lo'rus. The lower or right orifice of the stomach.

Ret'i-na. A very delicate membrane, lining the hinder two-thirds of the eye-ball. It is the continuation of the optic nerve.

Rhythm. A measure of anything according to the number of regularly occurring impulses.

Rigor Mortis. Stiffness of the entire body after death.

Rum. Product of distillation of fermented sugar cane.

Sa'crum. The triangular bone forming the posterior part of the pelvis, and terminating the vertebral column. It is a union of the 25th, 26th, 27th, 28th and 29th vertebræ into one great bone.

Sa-li'va. A thin watery liquid of the mouth, having the property of converting starch into sugar.

Sapid'ity. The quality of bodies that gives them taste.

Scle-rot'ic. The white of the eye. A tough, firm spheroidal case, the greater part of which is white and opaque.

Se-cre'tion. The separation of substances from the blood of animals, or from the juice of plants.

Sensibil'ity. The power which any tissue of the body has of causing changes inherent or excited on it to be perceived and recognized by the mind.

Se'rum. Watery part of animal fluids, as of blood or milk.

Skel'e-ton. The solid framework of the body of an animal.

Stimulant. Means of increasing the vitality of some organ or of the human system.

Sympathet'ic. A long double series of ganglia connected together by nervous cords.

Sys'to-le. The contraction of the heart—opposed to *diastole*.

Tac'tile. Perceptible to, or susceptible of, touch.

Tem'perature. The amount of heat which a body may communicate to other bodies.

Ten'don. A white cord attached at one end to a bone and at the other end to a muscle; the same as *sinew*.

Tho'rax. The chest; the part of the body between the neck and the abdomen.

Thoraç'ic. Pertaining to the thorax.

Tis'sue. A membranous organization of parts.

Tra'chea, or *Trach'ea.* A tube strengthened by cartilaginous rings extending from the larynx downward along the front part of the thorax, and passing into the thorax where it divides into two branches, a right and a left, called the *bronchi.*

Tym'pa-num, or *Drum.* Cavity of the middle ear, separated from the external ear by the tympanic membrane.

Vein. A vessel to convey venous blood to the heart.

Ven'tricle. Generally applied to the two cavities of the heart which communicate with the auricles. Applied also to other cavities in the body.

Ver'te-bra, pl. *Vertebræ.* One of the bones composing the vertebral column. It consists of a main part, called the body of the vertebra; and of seven projections called processes.

Vil'li. Soft projections or processes covering certain membranes.

Vit're-ous Humor. The transparent mass which fills the eye behind the crystalline lens.

Wine. Fermented juice of the grape.

Whisky. Product of distilling wheat, rye or corn.

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